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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE GEOLOGY OF ORE DEPOSITS.*

I.

I SHOULD hardly have ventured to talk on the subject of ore deposits to an audience which contains many men much more familiar with mines than I, if I had not approached the subject from a different point of view. The point of view from which the subject of ore deposits has been most frequently considered has been that of a study of ore deposits themselves. A geologist or mining engineer has studied this or that ore deposit, or a number of ore deposits in different districts, and has then generalized concerning the ore deposits of other districts, and perhaps of the world. I also have considered the subject of ore deposits to some extent from that point of view, but if I had done this only, I should not have ventured to give a general address upon the subject.

A number of years ago I began the study of the alterations of all rocks, by all processes and by all agents, in order, if possible, to ascertain how it is that the rocks change from one form to another. That rocks are metamorphosed has been known for many years. It has been realized that one mineral changes into another mineral;

* The Popular Scientific Lecture of the American Association for the Advancement of Science, complimentary to the citizens of Denver, delivered at Denver, Col., in the High School Auditorium, Monday evening, August 26, 1901.

that one rock changes into another rock; that rocks may have different textures, structures and compositions from those they originally had. The chief immediate agent producing these changes is underground water. Everywhere underground water permeates the rocks. Everywhere it is the medium of exchange by means of which the mineral particles are changed from one form to another.

In order, therefore, to understand this matter of the alterations of rocks, it became necessary to consider the flowage of the underground water; to attempt to ascertain, if possible, how it moves through the rocks, in what directions, to what depth it penetrates, whence it comes, whither it goes. After a certain number of principles and conclusions had been reached upon the alterations of all rocks, by all processes—and especially by the work of underground water with the help of heat derived from the igneous rocks, from dynamic action, and the increment due to depth—it seemed to me that many of the principles of ore deposition followed as corollaries from these general principles. Therefore, it is from this general point of view that the question is discussed to-night; not from that of a particular ore deposit or particular district.

For many years ore deposits have been classified into those which are produced (1) by the direct action of igneous agencies, (2) by the process of sedimentation and (3) by the action of underground water. There is no difference of opinion as to the existence of all these three classes; but there is a difference of opinion as to their relative importance. Some hold that deposits of igneous origin are of very great importance. By this I mean ore deposits which have been directly formed by some of the strange processes of vulcanism. Also it is certain that large quantities of ore, and especially the placer gold deposits, are largely the result of the process of sedimentation. But I hold that the greater number of ore deposits, those which contribute most to the wealth of Colorado, to the entire Cordilleran region, to the Lake Superior region, to the Mississippi Valley, to the Appalachian region, are those deposited by underground water; that is, they are the direct result of the work of the permeating solutions, which go for at least a considerable depth below the surface of the earth; and are taking material into solution all the time, depositing material from solution all the time. During the journey these underground waters take up from igneous, aqueous and metamorphic rocks the sparsely disseminated metallic material which is of consequence to man. This material is deposited in the openings of the rocks and within the more easily replaced rocks in sufficient abundance to form ore deposits. With the exception of iron, the quantity of metal which is contained in an ore is ordinarily small; in the case of gold, usually an exceedingly small fraction of one per cent.; in the case of silver, usually less than one per cent.; in the cases of copper, lead and zinc, from one per cent. to a rather high percentage, but in the great majority of instances less than 20 per cent. It therefore appears that the majority of so-called ores consist mainly of deposited materials other than the metals which are extracted from them. This predominant material is known as gangue, and plainly was deposited simultaneously with the ores, in the openings of the rocks, or else replacing rock material.

In a given instance to attempt to answer the question as to the source of the gold or the silver or any other metal, without at the same time considering the minerals with which it is associated, is futile. If we can answer the question as to where the gangue minerals came from, and how they got into the positions they now occupy, the question is in large measure answered as to

how the metal got there, and how it was deposited.

I shall not attempt to give all the evidence that the metallic ores and gangue are deposited by underground waters; but I wish to call attention to certain structures of veins which seem to favor this view. [At this point a number of lantern slides were used, illustrating the following statements.]

A massive rock may be produced by direct igneous agencies; sediments are arranged in strata and beds. But material showing a comb structure—or, as Posepny calls it, crustification—and the filling about particles of rock, is usually produced by underground water. No agent other than water can penetrate between the grains throughout a sandstone formation, or a conglomerate formation such as that of the Calumet and Heckla, or between the fragments of a great tuff formation such as that of the San Juan district of Colorado, and deposit material so as to transform them to hard rocks by cementing the particles. Many cracks and crevices, great and small, form in the rocks by the deformation to which they are subjected. Igneous material can intrude the rocks in a most intricate fashion and occupy these openings; yet in the great majority of instances the extremely intimate introduction of material is accounted for by transportation and deposition of material by underground waters. Those in this audience familiar with Colorado ore deposits know that many of the valuable minerals are in veins, many of them narrow, or between very small fragments within the rocks. Not only do the ores occur in the larger openings, but they frequently occur for some distance from the veins in the extremely minute, often subcapillary, openings of the wall rocks, or even replacing the individual particles of the wall rocks. But farther from the veins, if the metals are present at all, they are only in exceedingly minute quantities. In the larger openings and adjacent to these openings the values are chiefly found. These facts are beautifully illustrated at Cripple Creek. No known agent except underground water is capable of penetrating the very small, and especially the subcapillary, openings, and depositing material.

My primary assumption is, therefore, that the great majority of ores are deposited by underground waters at the places where they are now found. Nearly all that follows is confined to this class of ores. Ores directly produced by igneous processes, and those formed by processes of sedimentation, are only indirectly considered this evening.

The second fundamental principle which I shall try to develop is that the waters derived the ores from the outer part of the crust of the earth—the part which I have called the zone of fracture. Even as late as 1893, at the World's Fair Congress, at Chicago, it was argued by Posepny that the ores came from the barysphere, or heavy-sphere, from well down within the earth; although even Posepny conceded that the agent which transported and deposited the metals at the places where they are now found was underground water. Posepny's theory of the derivation of the ores from deep within the earth is a very attractive one; because, if it be true, the deeper a mine, the richer an ore deposit is likely to become. Indeed, it is the belief of 90 per cent. or more of prospectors that if they only could get deep enough, deposits of surpassing richness and magnitude would be developed. But it seems to me that the hypothesis that the ores are derived by the underground waters from deep within the earth has no foundation in fact. It is alike opposed to the principles of physics and to observations in the field.

It must be remembered that gravity is a gigantic force ever at work pulling toward

the center of the earth. And it must be remembered that all rocks are limited in strength. The strongest rock tested has a crushing strength of something more than 40,000 pounds per square inch. A column of such a rock 10 or 12 miles high would be crushed by its own weight. It is easily calculable that if we suppose the outer part of the crust of the earth to be composed only of the strongest rocks, and we imagine openings to exist in these rocks, then at a certain depth these cracks must be closed by the pressure. And this deduction has been experimentally proved. Professor Adams, of Montreal, has shown that rocks subjected to pressures in all directions greater than their crushing strength may be mashed, and no perceptible openings produced. Therefore, openings of great size cannot be assumed to exist below a very limited depth in the crust of the earth. This conclusion is fully verified by observation. By examining the rocks in the cores of mountain ranges where there has been deep denudation, we may see what has happened to them when well below the surface. In the Front Range of Colorado, and at various places in the world, where the rocks have been deformed at considerable depth below the surface of the earth (ignoring recent fractures which have been produced since the rocks came near or to the surface), the process has taken place without the formation of openings larger than those discernible only with the microscope. Therefore, from the point of view of pure physics, from the point of view of experiment, and from the point of view of observation alike, we reach the conclusion that no large or continuous cracks or crevices exist except for a very limited depth below the surface of the earth.

In order to deposit the metals and gangue of an ore deposit, a vigorous circulation is required. The vigorous circulation of underground water is necessarily confined to that part of the crust of the earth where there are continuous cracks and crevices of considerable size. As the openings decrease in size, the resistance due to friction increases rapidly; and where the openings are subcapillary, it is enormous, being in fact sufficient to practically check circulation. In Colorado a common gangue material is quartz. Springs have been analyzed, and it has been found that the water issuing from such springs bears perhaps one part in one hundred thousand, or one part in a million, of silica. It is probably rather uncommon for a solution to deposit as much as one part by weight in one hundred thousand of the gangue and ore material. If this be so and the gangue be quartz, in order to fill an opening with ore and gangue, at least 260,000 times as much water must have passed through it.

It therefore follows that if the majority of ore deposits are placed where they are by underground waters—and from this there seems no escape—the processes of their gathering and deposition must be mainly confined to the outer few miles of the crust of the earth. This is called the zone of fracture. *Therefore my second fundamental conclusion is that the ore deposits are derived from the zone of fracture.*

But is there an adequate source of supply of metallic material in the outer part of the crust of the earth? In answer to this question, it may be said that calculation clearly shows the relatively small quantities of ore which exist could have been derived from the zone of fracture, even if the rocks contain an exceedingly small fraction of one per cent. of metal. To illustrate, Mr. Buell has calculated for Professor Chamberlin, for the Wisconsin lead and zinc district, that if the richest portion of the district be taken, and it be assumed that the supply extended only one-half as far beyond the deposits as the radius of the productive area, and the depth of vertical distribution be confined

to 100 feet, one fourteen-hundredth of one per cent. of the metals in the rocks could supply all the lead and zinc which has been or is likely to be taken from the district. It is therefore not necessary to suppose that there is more than a minute quantity of metallic material in the zone of fracture, to furnish a supply adequate many times over to account for all the deposits which have been mined or are likely to be mined.

So far as the specific work of underground water is concerned, we have already seen that the metals for the ores are derived from the zone of fracture. But it does not follow that important supplies of metals to be later yielded to the water may not come from deeper within the earth. As a result of various causes, which cannot be discussed this evening, the igneous rocks rise from an unknown depth below the surface of the earth into the zone of fracture or even quite to the surface. Such igneous rocks bear materials out of which many important ore deposits are largely or wholly derived. Indeed, if we go far enough back in the history of the earth, all rocks were probably derived from the igneous rocks. So, directly or indirectly, the ultimate source from which ores are derived by underground water is igneous rocks, either ancient or modern. On this point there are no differences of opinion.

But there are differences of opinion as to the manner in which the ores are derived from the igneous rocks. Some geologists hold that the direct processes of igneous action produce many ores. They say that during the process of crystallization of the igneous rocks the ores are segregated by magmatic or pneumatolitic processes. There are cases in which this is probably true, as, for instance, the unimportant titaniferous iron ores of the Adirondacks and the Lake Superior region. Certain ores, as the tin ores, possibly have this origin. But it is yet unproved that the great mass of ores, which are known as the oxidized ores, the carbonate ores, the sulphide ores, and the tellurid ores, have been thus derived. We know of these classes of ores that a large part have been taken from the rocks and brought to their present positions by underground water. Why, then, assume some other process of segregation for which there is no adequate evidence, when we have a wholly adequate agent in underground water? In the great majority of cases the ores are taken from the igneous, sedimentary and metamorphic rocks by the underground waters; are carried to their present positions by the underground waters, and deposited by the underground waters at the places where they are now exploited.

The next question which naturally arises is the source of the underground water. It is believed that the water is predominantly of meteoric origin; in other words, is the water which falls from the atmosphere upon the valleys and hills and mountains of Colorado and other parts of the world. It is true that each igneous rock usually carries a small amount of water; and in the aggregate this amount may be very great. Indeed, it may be that all the water upon the surface of the earth and that in the openings of the zone of fracture was originally derived from the igneous rocks. But even if this be true, it does not follow that in a given district, at the particular epoch in which the ore deposits were formed, the water directly derived from the igneous rocks is adequate or even important in accounting for this deposition. As already explained, it is necessary to consider not only the ore but the gangue material with which it is related; and it has been seen that in order to deposit an ore and its accompanying gangue probably required tens of thousands or even hun-

dreds of thousands of times as much water. The vast quantity of water necessary cannot be derived from the igneous rocks present at a given time and place, although they may have contributed a portion of it. But it is held that the major portion of this vast quantity of water could only have been derived from the rainfall. *My third fundamental premise is, therefore, that the circulating underground water is mainly of meteoric origin.*

The question which now arises is the cause of the flowage of underground water. Why does it move? Until we know the force which drives it, we cannot know the manner in which it circulates. Geologists have frequently appealed to the great energy of the subterranean heat, due to depth or to igneous rocks, to drive this water. But this is not enough. How does this subterranean heat act in producing this circulation? A few miles west of Denver are the crystalline or core rocks of the Front Range. To the east of these there is a series of sedimentary beds, some of which are water-carriers, and which dip below impervious strata. The water rises to the surface at Denver. Why is this so? Simply because the water is at a higher level where it enters the formations than where it issues at the surface. The force which drives the water is gravitative stress. Gravitative stress is everywhere and all the time at work. The longer column is pulled downward with greater force than the shorter column. The difference in the height of the two columns is called head. Therefore, the water in the longer column moves downward, and that in the shorter upward. *We now reach my fourth fundamental premise: That gravitative stress is the chief cause of the circulation of underground water.*

The flowage of water in the Denver artesian basin does not require the force of the subterranean heat below. But there is a way in which the subterranean heat can promote the circulation of underground water; and, indeed, does. This is by heating it. When the water is heated as a result of the contact with igneous rocks, or heated because it penetrates deep into the earth, it expands. If it expands unequally, as it is likely to do, one column may become lighter than the other, even if they are of the same height. If so, circulation would be set up. This is the principle of hot-water systems of heating buildings. The heat of the fire expands the water and forms two columns of unequal density. Under this condition of affairs gravity pulls the denser column harder, and a circulation takes place. Therefore, the heat of the igneous rocks acting upon the underground solutions, or the heat of the rocks due simply to depth, provided the circulation be of sufficient speed, may result in flowage. Thus there are two causes which result in the underground circulation, which may work separately or together—(1) head, and (2) variable temperature. But in either case continuous movement of the water in a definite direction, or its circulation, is due to gravitative stress.

Therefore, we have these four fundamental premises: (1) *The chief class of ore deposits is segregated by underground water;* (2) *the source from which the water derives the metals is the zone of fracture;* (3) *the circulating underground water is mainly of meteoric origin;* (4) *the force which drives the water in its circulation is gravitative stress.*

It is now necessary to consider in some detail the manner in which underground water moves. For a long time I have realized that if underground water had a difference in head it might penetrate to a great depth and rise again to the surface; but I did not realize that it was not necessary to assume exceptional openings for such a circulation. I assumed that where such a circulation took place exceptionally favorable channels were available;

but a recent paper by Professor Slichter* upon the motion of ground waters showed me that this was an entirely unnecessary assumption, and gave me the additional data needed upon this point. This chart (Fig. 1) is a horizontal diagram. *A* represents one well and *B* another well, separated by a homogeneous porous medium. Into the well *B*, I pour water. In the well *A* there is no water at the outset; and the water flows from the well *B* to the well *A* through the medium. What is the path of the water? Its flowage is represented by the curved lines. Some of the water goes in a nearly direct course. Another part takes a somewhat curved course. Still other parts of the water follow a very indirect course, represented by the longer curved lines. All the available cross section is utilized. If, for instance, this room were filled with water, and water were running in at one place in the front end of the room and were escaping at one place in the rear end of the room in equal quantity, would the water simply follow the direct line between the two openings? You know perfectly well it would not. The entire available cross section of the room would be utilized, although the more direct course would be utilized to a greater extent than the more indirect course. This is intended to be illustrated on the chart (Fig. 1) by the lines representing the nearly direct courses being close together, and the lines representing the indirect courses being farther apart.

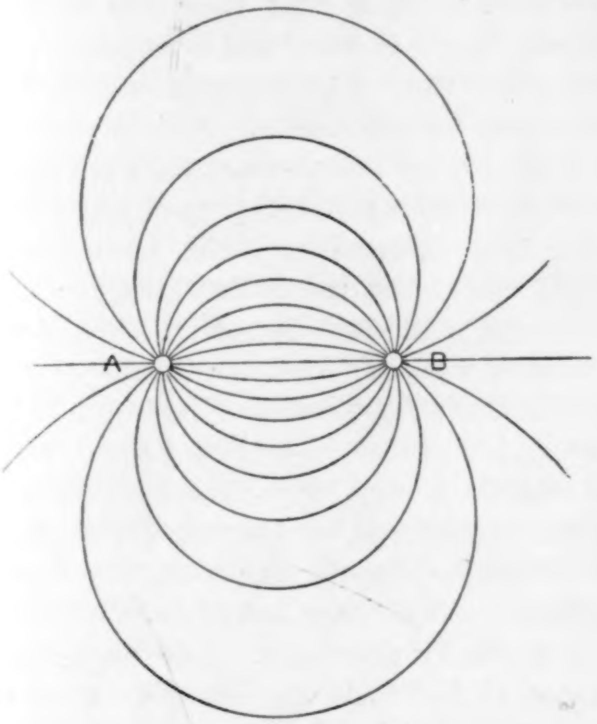

FIG. 1.

This chart (Fig. 1) then represents the horizontal circulation. If we pass to the vertical circulation the flowage is represented by this chart (Fig. 2). The water is being poured into the well *B* and passes to the well *A*. The water follows the course of the curved lines, so that with a difference in head equal to the difference in the level of the water in the two wells, a considerable part of the water being poured into *B* and passing through the homogeneous porous medium to *A* penetrates a considerable depth, from which it rises and enters the well *A*. Now what will be the limit in nature of the downward search of underground water? We have already given it. Manifestly the lowest limit of effective circulation at any place is the bottom of the zone of fracture at that place. The zone of flowage below is practically impervious. However, an impervious limiting stratum may exist at depths far less than the bottom of the zone of fracture. An impervious limiting stratum, perhaps a shale, may be found at a depth of 300 feet or less, or at any depth intermediate between this and the bottom of the zone of fracture for the strongest rocks. Where there are one or more pervious strata which are inclined, and above, below and between which are impervious formations, there may be two or more nearly independent circulations. To illustrate, at Denver, the

* 'Theoretical Investigation of the Motion of Ground Waters,' by C. S. Slichter, Nineteenth Ann. Rept. U. S. Geol. Surv., 1899, Pt. II., pp. 295–384.

porous strata of the Fox Hills, Laramie and Arapahoe formations have more or less independent circulations. If a limiting stratum be supposed to be half way down on the chart (Fig. 2) the lines of flow above

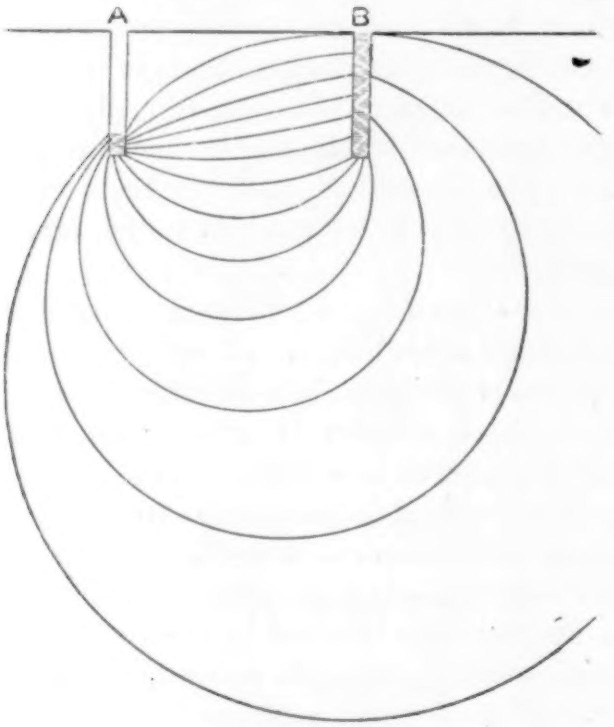

FIG. 2.

this stratum would not be as they are now, but would be flatter and would be limited by the impervious rock.

Under natural conditions, wherever there is an impervious rock there is a limit of some particular circulation in that direction. A limiting stratum may, therefore, be very near the surface, at the bottom of the zone of fracture or at any intermediate depth; and theoretically a moderate head is sufficient to do the work of driving the water to any of these depths. Indeed, there is no escape from the conclusion that at least some circulation does occur in the deeper parts of the zone of fracture with a very moderate head. Of course, in proportion as the head is great the circulation at depth is likely to be vigorous. But it may be objected that a deep circulation, while theoretically possible, must be exceedingly small in quantity, and consequently of comparatively little account in the deposition of ores. But the consideration of the underground circulation in reference to the Denver artesian wells shows that this objection has little weight. Moreover, the deeply circulating water, if less in quantity than that near the surface, takes a longer journey and is longer in contact with the rocks through which it is searching for the metals. Not only so, but it is at a higher temperature than the water at higher levels; and this also is favorable to taking mineral material in solution. And, finally, because it has a higher temperature, it has less viscosity. While the variable viscosity of water is not so very important in reference to circulation in supercapillary tubes, in capillary tubes, which constitute a very large fraction of underground openings, and especially those at considerable depth, the viscosity is important—the flowage increasing directly as the viscosity decreases. The viscosity of water at 90° C. is only one-fifth as much as it is at 0° C.; and, therefore, with a given head of water in capillary tubes, if the temperature be considerably increased—and but a moderate depth is required to give considerable increase—the water moves several times as fast as it would at the surface under conditions similar in all respects save temperature. Therefore, because of these three factors, long journey, high temperature and low viscosity, we cannot exclude the deep circulation from consideration. This circulation is, indeed, believed to be very important in the deposition of ores.

We are now prepared to consider the actual journey of underground water. Where water falls upon porous ground it finds innumerable openings through which it enters and begins its underground journey. This circulating water, as far as practicable, under the law of the minimum expenditure of energy, follows the paths of easiest resistance. But these are the larger

openings, because resistance due to friction along the walls and within the current is very much less per unit circulation in large than in small openings. While, therefore, water enters the ground at innumerable small openings, as it goes down it more and more seeks the larger openings. Once found, it holds to them. The farther it continues its journey, the greater the proportion of the water which follows the larger openings. But if this be true, the water in its descending course is more likely to be widely dispersed and in the smaller openings; and in its upward course more likely to be concentrated and in the larger openings.

We can now follow the course of underground water in detail, but in doing this it is necessary to consider the elements of the problem separately. It is only by passing from a simple case to the very complex one of nature that we can understand the latter. Here is a chart (Fig. 3) which shows the surface of a slope, the level of ground water and the flowage of water in the simplest imaginable case. In this illustration we have represented the surface of the earth and the level of ground water. By the level of ground water is meant the depth at which the water saturates the rocks—that is, where the water remains at practically a permanent level. Above this level the paths of circulation are practically vertical; below this level the paths are curved. Of the water which enters the slope of a hill and issues in the adjacent valley, a portion flows along the slope of the hill, a portion in a less direct route, and a portion in a very circuitous route. Below the level of ground water all the openings in the rocks, great and small, are filled with water. In the case represented I have supposed that all the water enters at a single point, *A*; and that all of it issues at a single point, *B*. The curved lines represent the flowage of the water through a homogeneous porous medium.

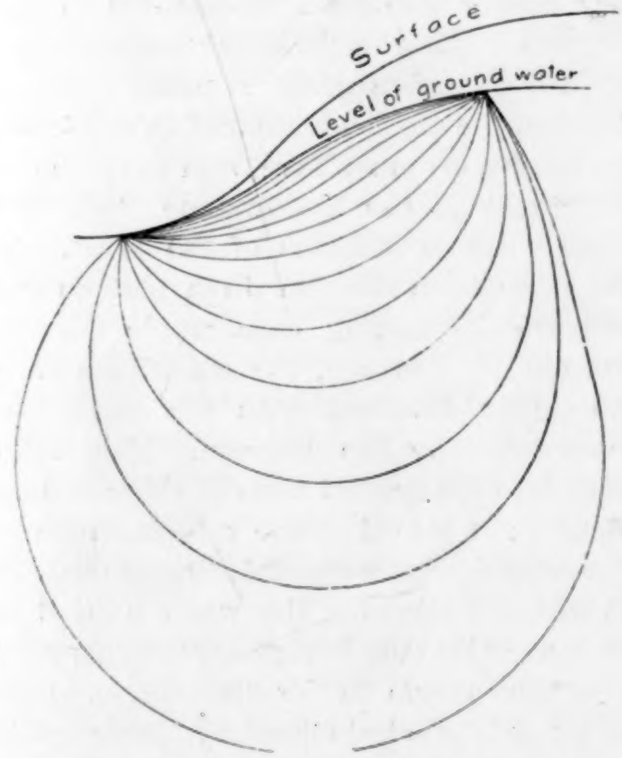

FIG. 3.

In the next chart (Fig. 4) I have supposed water to enter at three points and issue at one; and I have supposed the flowage from each point of entrance

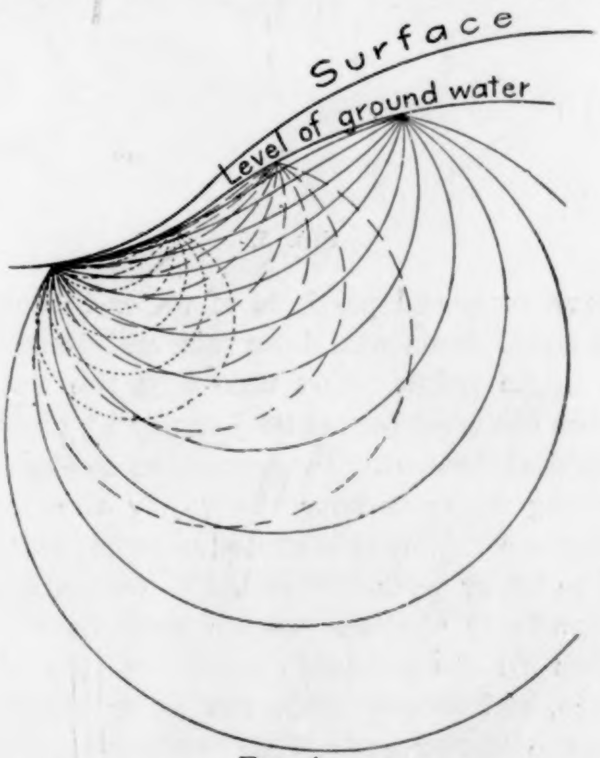

FIG. 4.

to occur just as if no water were entering anywhere else, and, therefore, the systems of flowage to be superimposed. Of course this is not a real case. Underground water does not diverge from a single point and converge at another point in independence of the water entering at other points. The water entering at innumerable points in vertical section and in horizontal section mutually interferes, and makes the course for any given particle of water rather simple. This I have tried to represent by another chart (Fig. 5). In this chart I

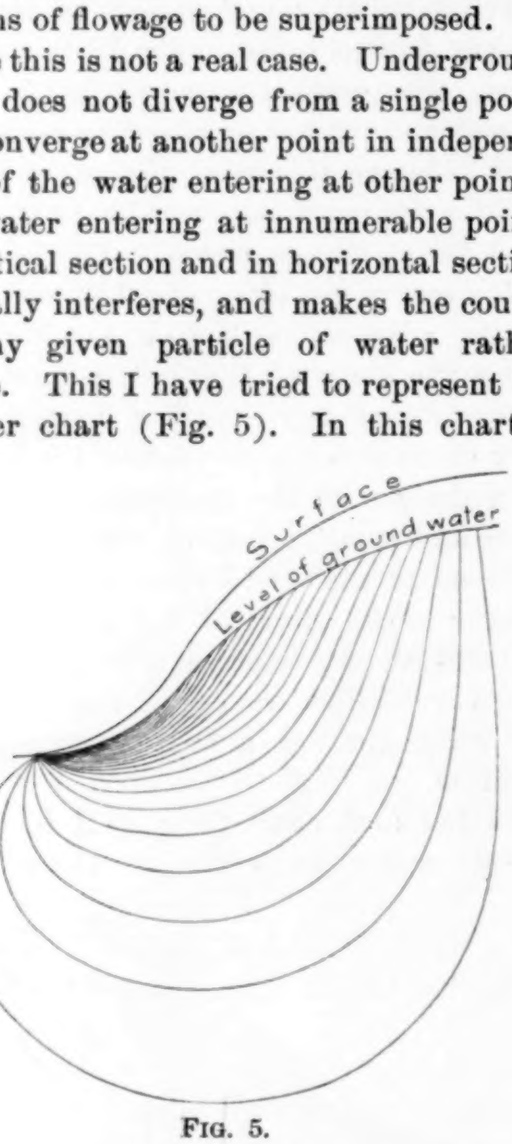

FIG. 5.

have supposed particles of water to enter at equal horizontal intervals, and issue at a single point. You note that the water near the crest begins its journey by almost vertical descent. In proportion as the entering water is near the valley the horizontal component becomes more important. The water near the valley follows a comparatively shallow course; but this water uses all the available space near the surface, and consequently the water entering at the higher ground necessarily follows a long, circuitous and deep course. The chart (Fig. 5), therefore, represents the flowage with many points of entrance and a single point of exit, where there is interference of the circulating waters.

A portion of the water follows an approximately direct path; a portion of it less direct paths; and a portion of it a very roundabout path. That is, the underground water, following the lines of least resistance, takes not only the direct passages, but also the indirect passages. The lines in the more direct path are closer together, and the indirect path farther apart. These facts have been ascertained by experiment and by mathematical analysis. But everywhere gravitative stress is the driving force. The case represented by the diagram (Fig. 5) is an ideal one. Under the complex conditions of nature there is usually great departure from the simplicity represented; but in some districts this ideal simplicity must have been approached. For instance, except for the disturbance due to cutting dikes, the circulation in the past in the San Juan district of Colorado must have been very nearly like that represented in the diagram. Early in Tertiary time there was in that district a great volcanic plateau. Early in the erosion history of this plateau, the conditions must have been the same as at present in the Yellowstone Park and other volcanic plateaus of the West. At the stage when the San Juan plateau was still the dominating topographic feature, but cut by canyons, the conditions were practically identical with the conditions represented by the diagram. The water sank into the ground upon the hills and the plateau; it issued at the valleys, much of it having first penetrated far below the level at which it issued. The water carried on its search for metals through the volcanics, almost as shown in the diagram, except in so far as it was influenced by larger cracks or crevices, or by cutting dikes, or by impervious layers.

The principles illustrated by these diagrams show it is not necessary that

there shall be a difference of elevation of thousands of feet between where the water enters and where it issues, in order that the rocks shall be searched for depths of thousands of feet. A few hundred feet is sufficient. Therefore, the underground waters, falling on the slopes, passing through the areas where they may gather material, and issuing at various places in the valleys, have an opportunity to pick up the ores, provided the metals exist in the rocks traversed. By the water the metals are carried to the places where they now are.

Thus far it has been supposed that the ground is uniformly porous, like an evenly grained sandstone without joint or fracture of any kind, in which the water can go in all directions with equal ease. But absolute uniformity does not exist in nature. The openings in rocks are never of uniform size; they are never equally distributed.

It is now necessary to take up the final important point in the circulation of underground water. So far as it can, it passes from small openings to large openings. Where the openings are small the resistance per unit area is very large. Where the openings are exceedingly small, the resistance is very great. Where the openings are large, the resistance is slight; and the water, following the lines of least resistance, travels to the extent that space permits in the trunk channels. To illustrate, every engineer knows that if water be carried in pipes from the hills to the mines, one pipe will carry vastly more water in a given time with a given head than many smaller pipes of the same aggregate cross section. This is because of friction, which increases rapidly as the cross section decreases. And water does the same thing in natural as in artificial pipes. Therefore, the underground water more and more follows the larger courses. It falls everywhere on the slopes of the hills; it enters the ground everywhere. Therefore, in its earlier course it is widely disseminated, and thus dispersed can most effectively pick up the valuable metals with which it comes into contact. But as the journey is continued, it collects more and more into the larger channels. But in the early part of the journey of ground water its vertical component is apt to be downward. But as it must sooner or later reach the surface, in the later part of its journey its vertical component is apt to be upward. However, it has just been seen that the early part of its course is apt to be in small openings, and the later part in larger openings. As it collects in the larger channels, it is more likely to be ascending. Therefore, upon the average—I say upon the average—descending water is mainly in the small openings, and ascending water mainly in the large channels.

It is now advisable to consider the circulation in definite vertical large, or trunk channels. Suppose half way down the slope there is a vertical opening of unusual size

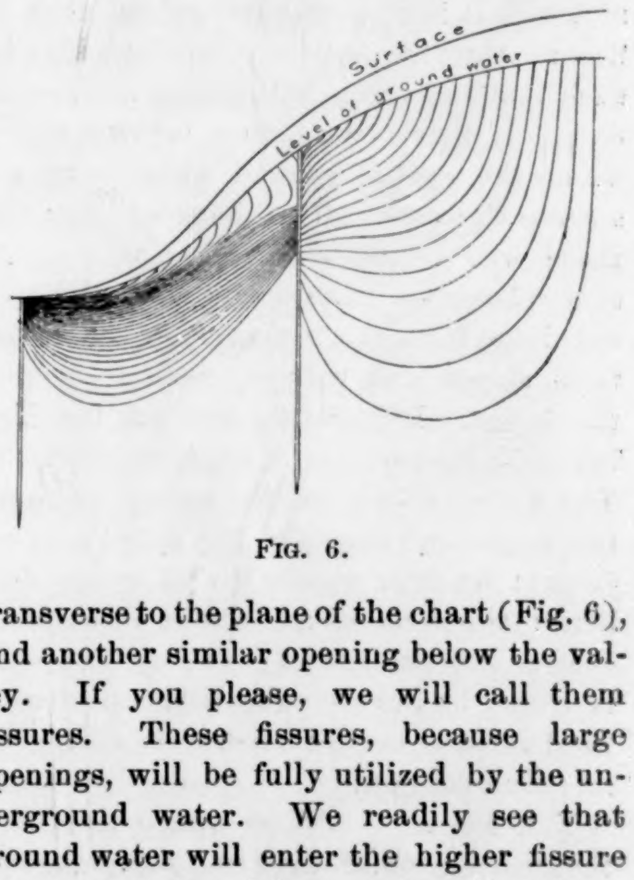

FIG. 6.

transverse to the plane of the chart (Fig. 6), and another similar opening below the valley. If you please, we will call them fissures. These fissures, because large openings, will be fully utilized by the underground water. We readily see that ground water will enter the higher fissure at many points and from various directions.

Ordinarily it will enter the upper part while it is still descending; it will enter the central part laterally; it will have begun its ascent before it enters the lower part. Therefore, a fissure upon the middle of a slope will be very likely to receive water from above, from the side and from below. But at a certain area of a fissure well up on the slope the water continuously received at the upper side of the fissure will escape laterally at the lower side. This water and that entering the ground below the upper fissure will make its way to the fissure below the valley. But here the level of ground water is at the surface. Consequently all the water entering this fissure will ascend quite to the surface, and issue as a spring. If there be a fissure at the crest we can see that the descending water will go a long way down; but the waters will nowhere be ascending. If there be a fissure on the slope, both descending and ascending waters will ordinarily be active; although it is of course recognized that in fissures thus located the conditions may be such that the waters will ascend or descend only. If there be a fissure below a valley where the level of ground water is at the surface the water will all be ascending; and there will be no descending water. At such places we have springs. Springs do not issue from the tops of mountains, but from slopes and valleys, most frequently the latter. Illustrating this are the Yellowstone Park springs of the Firehole River. The waters which feed the springs fall upon the crests and slopes of the mountains adjacent; on their way to the valley go deep below the surface, and at the Firehole ascend as hot springs and geysers. The water is driven by gravity due to a considerable head and the lower temperature of the descending column.

You are all doubtless aware that three theories are maintained as to the course of the waters which deposit ores. Some hold that the waters doing the work are descending; others that they are laterally moving; others that they are ascending. The first is known as the descension, the second as the lateral-secretion, and the third as the ascension theory. If my argument be correct as to a limit to the zone of fracture, fissures, as well as all other openings, must gradually become smaller and smaller, and finally die out altogether. Water in a fissure may descend or may ascend for a considerable distance; but it is perfectly clear that, so far as fissures are concerned, except for the small amount entering the surface openings, the water must enter laterally. Consequently, if we apply the lateral-secretion theory broadly enough, we may say that all the waters which feed the fissures are lateral-secreting waters. But if we are descensionists, and consider only the upper part of a fissure on the slope—and that is what many very naturally have done, because this is the part of the fissure most easily observed—we may say that the waters which are doing the work are descending waters. Or, if we are in such a district as that of the Comstock lode, in which are found great volumes of ascending water, we may say that the waters which are depositing the ores are ascending. All may be correct. But in the past Sandberger held that lateral-secreting waters in the narrowest sense did all the work, and he refused to believe that ascending and descending waters were of importance; and Posepny held that ascending waters did nearly all the work, and gave small consideration to the lateral-secreting and descending waters; whereas you see with perfect clearness that each theory is incomplete. All are needed; they supplement one another.

The next point to consider is why the metals are precipitated in veins. The salts of the valuable metals may come from any of the places visited by the oc-

cupying waters. If one take a number of chemical solutions in the laboratory, and dump them together in a beaker, probably precipitation will occur. These conditions are precisely those of underground solutions in trunk channels. The water from one source meets the water from another source in the trunk channels. Analyses show that waters from different sources have different compositions. They bear different metals and precipitating agents. When they come together in the trunk channels, and mingle, precipitation is likely to take place. You, who are practical mining men, like your veins to intersect, or two veins to unite. The explanation of the frequent increased values at or adjacent to an intersection is simply that the different trunk channels bear solutions of different kinds, and when they mingle at or near the intersections, ore precipitation is likely to occur. One solution may bear its mite of silver or gold, and the other the precipitating agent, or both solutions may carry the metals, and when the two come together the ore be thrown down. However, this is not the only way in which precipitation may take place. In many instances the precipitation is due to the wall rock. The wall rock, or the solutions furnished by it, react upon the solutions coming from somewhere else, and precipitation occurs. These two causes for precipitation are not the ones which are ordinarily mentioned in treatises on ore deposits. The causes commonly assigned in text-books for precipitation are the diminishing temperature and pressure of the rising solutions. While these are real causes for precipitation, I believe them to be subordinate to the influence of the mingling of solutions from various sources in the trunk channels, to the influence of the wall rocks, and especially to the first.

C. R. VAN HISE.

(*To be concluded.*)

THE PHYSICAL SCIENCES AT THE BRITISH ASSOCIATION.

THE meeting last September at Glasgow, which was attended by nineteen hundred persons, was smaller than the last two meetings held in that city, and fell slightly below the average of the British Association gatherings. This was chiefly the result of the unexpectedly small number of local associate members enrolled, accounted for by the fact that an International Exhibition with several collateral congresses had satisfied whatever desire the inhabitants of the Scotch metropolis may have had to increase their knowledge of scientific matters. The foreigners numbered only twenty-one, but some who might have attended this meeting had already been in Glasgow early in the summer as delegates to the jubilee celebration of the University. Since the president of the Association this year is one of the most distinguished physicists in Great Britain, it was natural to expect a large gathering of workers in his branch of science, but here also certain well-known names were missed from the list of members, which may likewise be attributed to the above cause. The meetings of all the sections were very conveniently held in the splendid University buildings on Gilmore Hill, the Physical Section holding its sessions in the Natural Philosophy Class Room, rendered famous by Sir William Thomson, now Lord Kelvin. The only criticism that could be made of the local arrangements was the absence of notices at the doors of each section indicating what paper was being read, but the same complaint has frequently been heard at our American Association meetings.

Professor Rücker's presidential address, which has already appeared in SCIENCE, was a scholarly defense of the atomic theory of matter, but some disappointment was manifested that the objections of its opponents were not definitely stated. Lord Kelvin, who seconded the vote of thanks to the

speaker by a short address of his own (as is customary in England), was rather bitter in his denunciation of those who did not accept the theories advanced. Hence it seems doubtful if the popular audience carried away a fair appreciation of the question. The two evening lectures were noteworthy because given by men whose names are household words in the scientific world. Professor Ramsay's topic was 'The Inert Constituents of the Atmosphere,' and though the unfortunate failure of the light prevented some of his diagrams from being visible at the proper time, the lucid explanations made the discourse entirely intelligible. Especially interesting was the description of the long and painstaking experiments and researches which resulted in the famous discovery of argon in 1894, followed in 1895 by that of helium, and in 1898 by that of three other elements to which the names of neon, krypton and xenon were applied. The second lecture, on 'The Movements of Plants,' by Mr. Francis Darwin, was a beautifully simple exposition of a most abstruse subject, namely, how gravity acted to force plants to grow along vertical lines. While the lecturer thought that plants might be classed as vegetable automata, yet he was inclined to believe that mind was always implicated in life, and that, with a fuller knowledge of consciousness, we should admit that the rudiments of the psychic element existed even in plants. There follows an abstract of the presidential addresses and of the work of the Sections of Mathematics and Physical Science, Chemistry and Engineering.

MATHEMATICS AND PHYSICAL SCIENCE.

The president of this Section was Major P. A. MacMahon, F.R.S., and his address dealt first with the position that mathematical science occupied at the beginning of the nineteenth century in the British Isles and on the continent of Europe. As regards organization and cooperation in mathematics, Germany, he thought, stood first now. The illustration offered by international cooperation in astronomy afforded a useful object lesson to all men of science, and might encourage those who had the ability and the opportunity to make strenuous efforts to further progress by bringing the work of many to a single focus. In pure science a free interchange of ideas was possible, but in applied physics the commercial spirit exercised an influence, and it was the duty of the Association to take an active attitude toward this blot on the page of applied science. The importance of science teaching in secondary schools had been overlooked. Those concerned in our industries had not seen the advantage of treating their workshops and manufactories as laboratories of research, and the Government had given too meager an endowment to scientific institutions and had failed adequately to encourage scientific men. At the present time, the number of workers is so large, the treatises and scientific journals so numerous, the ramifications of investigations so complicated that it was scarcely possible to acquire a competent knowledge of the progress being made in the many divisions of science. Hence the so-called specialist has come into being, and the word was often used as a term of opprobrium or as a symbol of narrow-mindedness. What is required is not the disparagement of the specialist, but the stamping out of narrow-mindedness, and of ignorance of the nature of the scientific spirit and of the life-work of those who devote their lives to scientific research. The specialist who wishes to accomplish work of the highest excellence must be learned in the resources of science and have constantly in mind its grandeur and its unity. Lord Kelvin and Professor Rücker offered the motion for a vote of thanks, and then the regular work of the

Section was begun. Papers were read by Professors A. Gray, F.R.S., J. S. Dunlop and A. Wood, on 'Elastic Fatigue as shown by Metals and Woods'; by Professor G. Quincke, of Heidelberg, on 'The Clearing of Turbid Solutions and the Influence of Light on the Motion of the Suspended Particles'; by Professor A. Gray, F.R.S., on 'The Relation between Temperature and Internal Viscosities of Solids'; by Professor W. Ramsay, F.R.S., and G. Senter, on 'Hydrostatic Pressure'; by E. H. Griffith, F.R.S., on 'The Freezing Points of Certain Dilute Solutions'; and by Dr. R. T. Glazebrook, F.R.S., on 'The Buildings of the National Physical Laboratory.' Dr. Glazebrook, who is the director of this new institution, gave a history and description of the building now being fitted up in Bushy Park, ten miles southwest of London, and described the objects for which it had been founded, as reported on pages 662–663 of SCIENCE.

On September 13 the Section was divided into two parts, Physics and the newly organized subsection of Astronomy. In the former Dr. Glazebrook read the report of the Committee on Electrical Standards, which stated that no evidence of any marked change in the relative values had shown itself. Mr. S. Skinner read a note on 'A Comparison of the Deposits in Silver Voltameters with different Solvents,' and Professor A. Schuster, F.R.S., presented one on 'The Conduction of Electricity through Mercury Vapor.' Dr. V. Crémieu, of Paris, spoke on 'The Magnetic Effects of Electric Convection' in which he showed that an electrically-charged body in motion has not the same electromagnetic properties as an electric current, but, as Lord Kelvin remarked, if these experiments are regarded as conclusive the present electromagnetic theory must be rejected. Other papers were by G. M. Minchin, F.R.S., on 'Photoelectric Cells'; by B. Hopkinson, on 'The Necessity for Postulating an Ether'; and by Professor F. C. Bose, on 'The Change of Conductivity of Metallic Particles under Cyclic Variations of Electromotive Force.' The Astronomical subsection met under the presidency of Professor H.H.Turner, F.R.S., of Oxford (who took the place of Dr. Copeland, Astronomer Royal for Scotland, detained by illness), and he delivered an address on cooperation in astronomical work, with special reference to the astrographic chart. While agreeing with Major MacMahon as to the value of cooperation, Professor Turner called attention to the harm that might result from undertaking too much and through the checking of original research. The most important astronomical papers were by Professor G. Forbes, F.R.S., on 'The Position of a Planet beyond Neptune,' and by Father A. L. Cortie, of Stonyhurst, who proved that the faculæ on the sun's surface followed the same law of drift as the spots. Professor Turner exhibited a copy of the first photograph of the spectrum of a lightning flash obtained by Professor E. C. Pickering, of Harvard Observatory.

At the next meeting of the Physical Section two papers, by Professor E. W. Morley and Mr. C. F. Brush, of Cleveland, were presented by the former gentleman, the first being on a new gauge for small pressures, designed especially to measure the pressure of aqueous vapor (which will be described in the *American Journal of Science*), and the second on the transmission of heat through water vapor. Other papers were by Messrs. C. Bedford and C. F. Green on 'A Method of Determining Specific Heats of Metals at Low Temperatures'; by Professor H. L. Callandar, F.R.S., on 'The Variation of the Specific Heat of Water'; two papers on the Lippmann electrometer by Messrs. F. G. Cottrell and J. A. Craw and one by Dr. M. W. Travers and G. Senter on 'A Comparison of Constant Volume and Con-

stant Pressure Scales for Hydrogen between 0° and 190° C.' The Committee on Radiation in a Magnetic Field also reported. The mathematicians of the Section met with the Educational Science Section in a joint discussion on the teaching of mathematics, opened by Professor J. Perry, F.R.S., of the Royal College of Science, South Kensington, and participated in by Professor A. R. Forsyth, F.R.S., of Cambridge, Professor A. W. Rücker, now principal of the University of London, Professor S. P. Thompson, F.R.S., of the same university, and others.

On Monday, the 16th, the Section again met in two departments—Mathematics and Physics. In the former, with Major MacMahon as chairman, there were papers by Professor G. Mittag-Leffler, of Stockholm, by Professor G. H. Darwin, F.R.S., by Professor A. G. Greenhill, F.R.S., and others, besides the report of the Committee on Tables of Certain Mathematical Functions. In the department of Physics, under Dr. Larmor, F.R.S., two interesting reports were presented, by Professor J. D. Everett F.R.S., for the Committee on Underground Temperature, in which the temperatures recorded in the Calumet and Hecla mines were compared with the temperatures in the deepest shaft in the world, situated in Upper Silesia, and the sixth report of the Committee on Seismological Investigations, drawn up by Professor J. Milne, F.R.S., which stated that there were 36 seismological stations abroad and in Great Britain provided with seismographs recommended by the Committee. Among the physical papers, Dr. Crémieu offered one on 'Gravitation' and Dr. C. E. Guillaume, also of Paris, sent as a basis for discussion a proposition for a new unit of pressure, called the megadyne per square centimeter, which differs little from the present atmospheric unit. Considering the status of meteorology in Scotland, surprisingly few communications in this science were offered, and these suffered from being scattered through two sections. In the Physical meeting just mentioned, there were two suggestive papers by Mr. W. N. Shaw, F.R.S., secretary of the London Meteorological Office, and Mr. R. W. Cohen on 'The Seasonal Variation of Air Temperature in the British Isles and its Relation to Wind Direction,' and on 'The Effect of Sea Temperature on the Seasonal Variation of Air Temperature of the British Isles.' The next day the department of Meteorology met under Professor Turner, but, excepting the report of the Committee on the Ben Nevis Observatory, which was drawn up, as usual, by that Nestor among meteorologists, Dr. Alexander Buchan, F.R.S., the sole paper was by Mr. F. N. Denison, of Victoria, B.C., on 'The Seismograph as a Sensitive Barometer.' The author concluded that since the earth is depressed under areas of high barometric pressure and elevated under areas of low pressure, horizontal pendulums might warn the advent of great Atlantic storms before they reached the west coast of Ireland, but in the discussion that followed, doubt was expressed as to whether the observed effect had been assigned to the right cause. On account of the interest of the president of the Geographical Section, Dr. H. R. Mill, and of its recorder, Mr. H. N. Dickson, in meteorology, their Section also received three papers relating to this science, including one by Mr. Dickson on 'The Mean Temperature of the Atmosphere and the Causes of Glacial Periods.' 'The Systematic Exploration of the Atmosphere at Sea by Means of Kites,' illustrated by the first meteorological records high above the Atlantic, was discussed by the writer who, being a member of two sectional committees, was able to urge the grant of money appropriated for conducting meteorological researches with kites in Great Britain. Mr. W. N. Shaw exhibited to the Geographical Section a series of

twenty-three daily weather maps that were published in various parts of the world at the commencement of the twentieth century. With the exception of Africa, only a small portion of the north of which continent was mapped, South America and a part of eastern Asia, every part of the world has charted each day the weather conditions prevailing over it.

The communication that attracted the greatest popular interest in the Physical Section was by Lord Kelvin on 'The Absolute Amount of Gravitational Matter in any Large Volume of Interstellar Space.' This was a summary of his article in the *Philosophical Magazine* for August (see also *Nature* of October 24), the conclusion being that the matter contained in the universe could not be much more than a thousand million times the mass of the sun, the number of these bodies, estimated at one thousand million, occupying only twenty-seven thousandths of the proportion of space in the universe. Dr. Glazebrook then opened a discussion on optical glass and explained the assistance which the National Physical Laboratory might render in determining the properties it should possess and the best forms of lenses for various purposes. After the reading of several optical papers, Dr. W. J. S. Lockyer, assistant director of the Solar Physics Laboratory at South Kensington, spoke on the evidence of a thirty-five-year period in the occurrence of sunspots, which coincided with the climatic variations indicated by Professor Brückner, of Berne, and with the frequency of auroras and magnetic storms observed since 1833. The closing session of the Section on September 18 was mostly devoted to the magnetic papers. A report presented by the Committee on the Determination of Magnetic Force on board Ship related to the instruments supplied to the English antarctic ship *Discovery* and to the German antarctic ship *Gauss*. Captain E. W. Creak, F.R.S., described a new form of instrument for observing the magnetic dip and intensity at sea which was designed to replace Fox's apparatus. Lloyd's needles are applied to an instrument that can be used on a gimbal-table on board ship and the *Discovery* and the *Gauss* have been so fitted. The numerous communications to the Physical Section were of a high order and, considering the technical and special nature of many of them, the attendance was well maintained.

CHEMISTRY.

Professor Percy F. Franklin, F.R.S., Professor of Chemistry in the University of Birmingham, delivered the inaugural address, as president of the Section, on the subject of 'The Position of British Chemistry at the Dawn of the Twentieth Century.' He first pointed out that the history of British chemistry, as indeed of British science in general, was remarkable in that it was made up almost entirely of achievements which were the result of private enterprise. The foundation of University College, and other institutions for higher education, by private initiation, and without a particle of assistance from the public exchequer, was quite in keeping with the history of a country in which it was recognized that the Government did not lead, but only followed where it was drawn or propelled. There could be no doubt that the extended cultivation of scientific chemistry in Great Britain, which was such a noticeable feature of the concluding years of the nineteenth century, has been greatly assisted by the research scholarships open to all branches of science and paid with the income produced by the surplus from the Exhibition of 1851. Until recently it had been the feeling of a powerful majority that public money should only be spent in such a way as directly to benefit very large numbers, and in the case of educational funds, therefore, it was only their utilization for

the benefit of the masses that would be entertained. Now, in the matter of higher scientific education, at any rate, it was becoming more and more widely recognized that its starvation, through attention being exclusively directed to the low-level education of the masses, was defeating the very ends which this policy had in view. It was rapidly dawning upon many that 'the greatest Empire which the world has ever seen' could not be maintained unless Englishmen cast off insular prejudices and traditions and made a careful study of those points in which other nations were their superiors, with a view to intelligent adaptation and development, as distinguished from mere initiation, of their methods to particular needs of the British Isles. If the higher teaching of science was to be really encouraged, the first necessity was that this higher teaching should offer a sufficiently attractive career to the man of ambition as well as to the enthusiast. It was not reasonable to fix a definite stipend to a particular chair, and should the best man be required the best price must be paid for him, while, if the British universities were to keep abreast of those of other countries, the chair must be thrown open to all the world. The period of academic study should be extended from three years to five, and the migration of students from one university to another ought to be encouraged. Higher education and true universities were among the most potent factors in breaking down the hereditary stratification of society and in minimizing the advantages depending upon the accident of birth, so that, with the greatly enhanced facilities which must be provided for students without means, they should afford in the future, even more than they had done in the past, an avenue for the humblest boy of talent to that position which he was, by natural endowment and by his own exertion, best fitted to fill in the interests of the state. British chemical work at the dawn of the twentieth century is satisfactory in many ways, for while almost all the great problems are being worked at, some of the recent progress of chemical science is more or less specifically British, *e. g.*, the isolated labors of Dr. Perkin in the field of magnetic rotatory power; Sir William Crookes's exploration of the phenomena occurring in high vacua; the researches of Abney, Russell and Hartley on the absorption spectra of organic compounds; the investigations of Harold Dixon and Brereton Baker of the behavior of substances in the complete absence of moisture; the extension by Pope and Smiles of asymmetric atoms; the near approach to the absolute zero of temperature by Dewar; and those marvelous discoveries of Rayleigh and Ramsay which have not only introduced us to five new aerial elements, but have revealed the existence of a hitherto unknown type of matter, which is apparently incapable of entering into chemical combination at all.

After the usual vote of thanks, moved by Sir Henry Roscoe, F.R.S., and seconded by Dr. T. E. Thorpe, F.R.S., the Section proceeded to the reading and discussion of papers. Dr. W. T. Lawrence brought forward the question of duty-free alcohol for chemical laboratories. He pointed out that workers in England were placed at a great disadvantage in comparison with workers in Continental laboratories, owing to the charge made on alcohol which was required in very large quantities in research. Abroad, when duties were exacted, they were remitted in the case of chemical laboratories so as not to impede the progress of the work of investigation. It was stated by others that some researches had been stopped half-way on account of this extra expense. Professor A. Michael, of Tufts College, Mass., explained that in the United States the duties were remitted when application was duly

made by the president of an educational institute. As a result of the discussion a committee was appointed to take what steps it could to procure duty-free alcohol and ether for chemical research. Dr. A. G. Green read a paper on 'The Decadence of the Coal Tar Industry in Great Britain and its Growth in Germany' of which an abstract was given on page 663 of SCIENCE. The report of the Committee on preparing a new Series of Wave-length Tables of the Spectra of the Elements was presented. The next day, after papers by Professor A. Brown on 'Enzyme Action,' and by Professor W. Marckwald, of Berlin, on 'Radium,' with demonstrations, the Section resolved itself into parts, one, under the president, considering sanitary and allied matters; the other, under Sir William Roberts-Austen, F.R.S., hearing metallurgical papers. In the former subsection, Professor E. A. Letts read a paper by himself and Mr. R. F. Blake on 'The Chemical and Biological Changes occurring during the Treatment of Sewage by the so-called Bacteria Beds,' in which it was pointed out that in the bacterial treatment of sewage in contact beds the organic nitrogen in the crude sewage was not all converted into the oxidized form of nitrate, this loss being partially due to the formation of free nitrogen, which was either evolved as gas or carried away dissolved in the effluent, and partly due to nitrogen absorbed into the tissues of animals and plants that feed on the sewage. Dr. S. Rideal in the next paper pointed out that the loss of nitrogen was caused in part by a black humus substance, allied to peat, which he had found was formed in all the present methods of bacterial process. This substance contained seven per cent. of nitrogen and was so stable that it did not decompose or give rise to smell, even if it was broken. Dr. Rideal also contributed a paper on 'Sulphuric Acid as a Typhoid Disinfectant,' in which he said that the outbreak of enteric fever among the troops in South Africa had led Dr. Porter and himself to try to find a chemical salt that could be added to infected water by soldiers on the march and would insure the death of the typhoid germ, if present. Such a salt is sodium bisulphate, and a gram to the pint, after fifteen minutes, purified the water, while four grams of sulphuric acid to the gallon freed sewage or drainage water from typhoid organisms. Mr. Wm. Ackroyd read a paper on 'The Inverse Relation of Chlorine to Rainfall,' in which he showed that when daily estimations of the amount of chlorine were made it clearly appeared that minimum amounts of rainfall were marked by maximum amounts of chlorine contents and *vice versa*. Mr. Ackroyd also detailed the results of his investigation of the distribution of chlorine in Yorkshire. A report was made by the Committee on the Relation between the Absorption Spectra and Chemical Constitution of Organic Substances.

Among the papers before the Metallurgical subsection, one of the most interesting was on 'The Minute Structure of Metals,' by Mr. G. T. Beilby, from which it appeared that the microscopical examination of metallic surfaces, produced in various ways, showed that the metal substance appeared in them as minute granules or scales, or as a transparent glass-like substance. The persistence of these minute scales under all kinds of mechanical and thermal treatment, the remarkable uniformity of their size and appearance in metals of all the leading groups, their disappearance into the transparent form and their reappearance again, apparently unchanged in size or otherwise, all these seemed to afford fair ground for the conjecture that they were in some way definite units in the structure of metals. Mr. Beilby also submitted a joint paper by

himself and Professor G. G. Henderson on 'The Action of Ammonia on Metals at High Temperatures,' which stated that the physical effect of the treatment in every case was to disintegrate the metals completely, while a large proportion of the ammonia was resolved into its elements. Three papers on aluminum and its alloys, together with the report of the Committee on the Nature of Alloys, were presented.

The papers on organic chemistry, to which September 16 was devoted, drew but a small audience, owing to their highly technical nature. The reports of the Committees on Isometric Napthalene Derivatives and on Isomorphous Derivatives of Benzene were taken as read. Professor A. Michael, of Tufts College, contributed three papers, one being on 'The Genesis of Matter,' in which he assumed that at the birth of matter there were two forms of 'protyle' corpuscles endowed with opposite polarity and only two forces—gravitation and chemical affinity—the temperature being near the absolute zero. Gravitation acted on these corpuscles, and when they came within the sphere of chemical affinity they united, converting part of their chemical energy into heat. It was probable that the non-metals in the genesis of matter would be first formed, and that as the temperature decreased the metallic elements began to form. At the next meeting of the Section the papers on general and physical chemistry were so numerous that it was necessary strictly to limit the time of each speaker. Professor J. Sakurai, of Tokio, speaking on 'Some Points in Chemical Education,' said that chemical education, as at present carried on, was inefficient and unsatisfactory. Chemical education was a sound course for those who would become chemists or for those who applied that science in special directions, but it was no less important for its educational value in secondary schools. Nevertheless, modern chemistry was still taught largely in the same dry and descriptive way as in the old days. He deprecated the term 'physical chemistry' as misleading and suggested that 'general chemistry' be used in its stead. Chemical laboratories in universities and colleges, he thought, should be institutions which contributed to the sum total of the knowledge in which men were trained and not mere workshops for apprentices. In the discussion that followed it was the general opinion that a thorough training in analysis should precede research work. Mr. W. Thomson read a practical paper on the 'Detection and Estimation of Arsenic in Beer and Articles of Food,' and Dr. E. F. Armstrong discussed 'The Equilibrium Law as Applied to Salt Separation and to the Formation of Oceanic Salt Deposits.' Its application to the formation of deposits, of potash and other salts, formed by the gradual drying up of ancient seas, is of interest and from a model, representing the successive changes observed on concentration of solutions containing several inorganic salts, it was possible to forecast the order in which salts would separate on concentration, and also the relative amounts deposited at any stage. The Committee on the Bibliography of Spectroscopy reported. At the closing session of the Section Dr. J. Gibson read a paper on 'The Electrolytic Conductivity of Halogen Acid Solutions,' in which he showed that there was a marked difference in the chemical behavior of the solutions of acids, according as the concentrations were above or below the concentrations corresponding to their respective maximal specific conductivities. Mr. P. J. Hartog, in describing 'The Flame Coloration and Spectrum of the Nickel Compounds,' said that nickel acetate produced an evanescent purple tinge and a persistent red coloration in the Bunsen flame. Professor Smithells remarked that, although experiments with nickel had been made for

years this property had not been observed, and the coloration perhaps might not be due to nickel. After papers by Dr. Farmer, on 'The Methods of Determining the Hydrolytic Dissociation of Salts, and by Dr. J. S. Patterson, on 'The Influence of Solvents on the Rotation of Optically Active Compounds,' the meeting terminated, having been less well attended, in spite of the interesting papers, than was the case at Bradford last year.

ENGINEERING.

This Section suffered severely in coming immediately after the assembling at Glasgow of the important International Engineering Congress, the Congress of Naval Architects and the Electricians' Association, all of which detracted from both papers and members. As a consequence, not a single paper on marine engineering, and only two papers pertaining to electricity were offered to the Section this year.

The president, Col. R. E. Crompton, M.Inst.C.E., in his address discussed first some of the interesting problems presented by recent development in means of locomotion on land, which demand the best thought, not only of our engineers, but of every one interested in the improvement in the means of traveling and in the more rapid transportation of goods. During the past few years a great improvement in the speed of trains and in the comfort of passengers on the American and Continental railways has been made, and while it appears that England has now been beaten in the matter of extreme speed on railways, it is probable that the English railways still provide a larger number of rapid trains than do either the American, German or French. The speed limit of railways of the present system of construction is reached at about sixty-five or seventy miles an hour, and it is improbable that anything greatly in excess of seventy miles an hour will be attained until an entirely new system of construction is instituted. The high speed service contemplated intends to obtain speed exceeding one hundred miles an hour by providing electrical means of haulage sufficient to propel light trains consisting of a single or, at most, a few cars run at short intervals of time. In the United Kingdom there are only a few journeys of sufficient length to make saving of time of great importance, but the case is far different in America and on the Continent where the business centers are much farther apart, and this topographical question would cause our English engineers to be at a disadvantage. A most important problem in locomotion is that caused by the congestion of street traffic in towns, and although the provision of electric tramways is undoubtedly an economical means of carrying passengers, yet these tramways could not be laid in existing thoroughfares without considerably reducing the total road-carrying capacity at times of heavy pressure of traffic, and so both for ordinary and pleasure transportation it appears probable that a motor-car service carried out on well-made roads would compete favorably with, and in many ways might be preferable to, tramway service. One of the topics that has been most strongly discussed during the past year is the position which Great Britain holds, relatively to other countries, as regards supremacy in engineering matters. The chief difference between the manufacturer here and the manufacturer in America is that the latter invariably makes goods in large quantities to standard patterns, which is much less the case in England. Many years ago, Sir Joseph Whitworth impressed on the world the importance in mechanical engineering of extreme accuracy and of securing the accurate fit and interchangeability of parts by standard gauges, but these ideas have not been acted upon to the extent that they should. Up to the present time the

Board of Trade has dealt with the simple standards of weight, capacity and length, but in other countries national standardizing laboratories have been provided. At last, through the exertion of the council of the Royal Society, the British Government has been moved to give a grant in aid and to cooperate with the Royal Society to establish a National Physical Laboratory. The vote of thanks to Col. Crompton for his address was moved by Sir Alexander Binnie and seconded by Sir Frederick Bramwell.

Mr. D. H. Morton, M.Inst.C.E., spoke on 'The Mechanical Exhibits of the Glasgow Exhibition,' which he said were, in general, disappointing, because in many departments the international character to which the Exhibition, as a whole, laid claim, was entirely wanting; because some of the most important developments in recent years were illustrated inadequately or not at all, and because the Exhibition failed to give any full idea of the magnitude and the variety of those enterprises which have made the city of Glasgow, with its surroundings within a radius of thirty miles, one of the world's great centers in metallurgy, mechanical engineering and shipbuilding. The collection of ship models historical and contemporary, was probably the finest demonstration of Clyde naval architecture ever seen, although marine engineering was so inadequately represented elsewhere. Nevertheless, the dominant Exhibits were the trophies in steel, and the exhibition might, indeed, be said to mark the triumph of steel, and particularly of cast steel. Mr. John R. Wigham explained a method of employing petroleum as an illuminant for beacons and buoys, to give a continuous light for a month or longer without any attention whatever. He exhibited also a 'New Scintillating Lighthouse Light,' by which the sailor was not deprived of the benefit of the powerful flash of the revolving lense, and yet did not have to pick it up at intervals, for this light is continually visible, the lenses being so placed with regard to each other and so revolved that the impression of the flash of one beam remains on the retina of the observer's eye till that of the succeeding beam takes its place, the practical effect produced being a continuously visible scintillating light. Mr. J. E. Petavel described a recording manometer for high-pressure gas explosions, in which elastic compression of metal replaces the spring of the ordinary indicator, a movement of a thousandth of an inch, corresponding to a pressure of 1,200 pounds per square inch, being shown by a ray of light deflected on to a recording cylinder. On the following day Mr. Norman D. MacDonald, of Edinburgh, read a comprehensive and interesting paper on 'Railway Rolling Stock, Present and Future.' Outside Great Britain it appeared settled that the compound locomotive would be the engine of the future. The boiler pressures, both in America and on the Continent, are much higher than in England, and for English roads the American type of engine, with equalizing levers and water-tube grate, offered advantages. In the discussion of the paper the progressive character of railway engineering in the United States was attributed to the attention paid by American universities to the testing of locomotives, and also to the good work done by the various railway clubs in spreading the knowledge of locomotive practice among young engineers. Mr. P. Bunau-Varilla, formerly engineer-in-chief of the Panama Canal, spoke on the relative advantages of the Nicaraguan and Panama routes for a canal from the Atlantic to the Pacific, favoring the latter on account of the masonry dam, which, with the locks, must be built and maintained in a country subject to frequent earthquakes, if the former be chosen. Moreover, ships would there encounter violent gales, strong

river currents, constant changes of depth, and many curves of short radius.

Monday is usually devoted to electrical engineering but, as already remarked, there were but two papers approaching that character this year. Mr. Killingworth Hedges contributed a paper on 'The Protection of Public Buildings from Lightning,' remarking that in 1888 the subject had been discussed jointly by the Physicists and Engineers of the Association, but that there had been no official report as to the effect of lightning strokes upon buildings protected by conductors since the Lightning Rod Conference of 1882. In the discussion it was said that architects could not be expected to pay more attention to protection of buildings from lightning until engineers had definitely decided what practice should be followed, there being at present many conflicting views. 'The Commercial Importance of Aluminium' and 'Aluminum as a Fuel,' were discussed respectively by Professor E. Wilson and Sir Roberts-Austen, F.R.S., the former considering chiefly its advantages as an electrical conductor. Mr. J. Dillon described a method of recording soundings by photography, for the use of engineers; Dr. Vaughan Cornish discussed the height and length of waves observed at sea, and Mr. R. L. Jack showed pictures of native bridges in Western China.

Two reports of committees were presented to this Section. Professor H. S. Hele-Shaw made a preliminary report for the Committee on Resistance of Road Vehicles to Traction, from which it appeared that some work had been done with a motor-car and experiments had been made on an artificial track so as to test the resistance of various materials. Mr. W. H. Price reported for the Committee on the Small Screw Gauge that, while it had been recommended last year that the thread of the British Association screw-gauge should be altered in certain particulars, and the proposals had attracted much attention, yet so far the recommendations had had no practical results. Professor G. Forbes explained a portable folding range-finder, for use with infantry, based on the instrument of Adie and utilizing stereoscopic vision. After papers by Mr. Mark Barr, describing his ingenious machines for engraving the matrices used in type-founding, by Mr. C. R Garrard, on 'Recent Development of Chain Driving,' by Mr. T. A. Hearson, on 'Measurement of the Hardness of Materials by Indentation by a Steel Sphere,' by Mr. E. T. Edwards, on 'The Critical Point in Rolled Steel Joists' and by Mr. J. W. Thomas, on 'Air Currents in Churches' the Section adjourned a day before the other sections. Notwithstanding the paucity of papers, they were of fair quality and covered a wide range of subjects.

A. LAWRENCE ROTCH.

BLUE HILL METEOROLOGICAL OBSERVATORY.

SCIENTIFIC BOOKS.

Smokeless Powder, Nitro-cellulose and Theory of the Cellulose Molecule. By JOHN B. BERNADOU, Lieutenant U. S. Navy. N. Y., John Wiley & Sons. 1901.

This work consists of eighty pages of new matter and of one hundred and thirteen pages of translation and reprints. The newly presented portion treats of: (1) Origin of the cellulose nitrates; the names by which they have been sometimes designated; and the meanings that the author gives to the terms he employs; (2) to 'the earlier views as to nitro-cellulose composition and constitution'; (3) to 'the conception of progression in relation to composition and constitution'; (4) to 'solutions of nitro-cellulose' and 'theory of the cellulose molecule.' It will be observed that in this brief space the author has set for himself a most ambitious program, especially as he applies himself to the solution of one of the unsolved problems of chemistry and one which chemists have regarded as presenting the most profound difficulties. Naturally those chemists into whose hands this book may come would turn at once

to the author's 'theory of the cellulose molecule,' curious to ascertain the data upon which the author's theory is based, the methods of reasoning by which he arrives at his conclusions, and the form that his theory takes. He will find that it is based on the statements of Cross and Bevan that in mercerizing cellulose with sodium hydroxide a definite reaction takes place 'in the molecular ratio $C_{12}H_{20}O_{10}$: 2 NaOH accompanied by combination with water (hydration)'; that the compound thus formed is decomposed on washing with water, 'the cellulose appearing in a modified form, viz., as the hydrate $C_{12}H_{20}O_{10} \cdot H_2O$'; that by treatment with alcohol 'one half of the alkali is removed * * * the reacting groups remaining associated in the ratio $C_{12}H_{20}O_{10}$. NaOH'; that the process of mercerization is accelerated 'on exposure to a lye of 1.225 - 1.275 sp. gr.' * * * 'by reduction of temperature,' which, Bernadou states, presents 'an analogy to the increased solubility of nitro-cellulose in ether and ether-alcohol upon application of cold'; that the quantitative regeneration of cellulose from thio-carbonate solutions and the saline character of aqueous solvents of cellulose led Cross and Bevan to express the belief that cellulose yields only under the simultaneous strain of acid and basic groups, and to assume, 'that the OH groups in cellulose are of similarly opposite function,' but 'that apart from any hypotheses, we may lay stress on the fact that these processes (of dissolving cellulose) have the common feature of attacking cellulose in the two directions corresponding with those of electrolytic strain.'

With these data and some few experiments of his own on solubility at low temperatures, Bernadou sets out to demonstrate the constitution of the cellulose molecule. He finds it necessary, however, at the outset to assume that ethyl hydroxide has the constitution which chemists have assigned to dimethyl oxide, and then taking as his empirical formula $C_{12}H_{20}O_{10}$, without giving any experimental data for doing so, he writes the constitutional formula for cellulose as a closed chain with double bonds for the central carbon atoms, notwithstanding that Cross and Bevan (the authority he quotes) in speaking of the celluloses say, on page 2 of 'Cellulose,' 1895: "Their reactions are those of 'saturated' compounds. Their empirical formulæ and relationships to the carbohydrates of lower molecular weight further indicate 'single-bond' linking of their C atoms as exclusively prevailing." On page 81 of 'Researches on Cellulose,' 1901, Cross and Bevan give a ring formula for cellulose as proposed by Vignon, but it is quite different from any given by Bernadou and the recent experimental data which suggest such an arrangement are cited. Having thus obtained a 'satisfied' molecule, Bernadou notes that the existence of the 'double central carbon bonds' permits the formula for the molecule, '*on its entering into combination*,' to be written with its four 'ethylene' bonds as linking, and then that, 'without radical modification,' these median bonds may be terminal. By now splitting this last molecule transversely he obtains the formula for his $C_6H_{10}O_5$, which he states 'is the simplest expression for cellulose' and 'represents not the molecule, but the type unit of cellulose as it enters into combination through its four free single carbon bonds,' and with this 'type unit' he proceeds to build 'polymers' exhibiting his 2-phase and 5-phase molecules, the latter being a cycle.

Of these he says, "It is evident that under such an assumption the molecule may possess an infinity of phases. On this assumption, and, it seems to me, on this assumption only, may we account for definite chemical composition of the cellular form in the plant structure. For we may regard the cell as built up from an aggregate of molecules of identical composition but of progressively varying numerical phase. The cell may begin with molecules of low phase and end with molecules of high phase, or conversely."

Again, "The conventional ring-formed combination of elemental particles shown in the polyphase molecule strongly suggests the vortex-ring theory of the composition of matter (as applicable to the *molecule*)."

And again, "Such a molecule would increase in amplitude according to the number of elemental particles entering into its composition; and the thought suggests itself that *progressive variation in the amplitude of the molecular ring is a characteristic of organic life*. Or, conversely, we may state that we may seek for the beginnings

of organic life—or at least of plant life—in the polymerization of the carbohydrates."

Lieutenant Bernadou seems to misconceive the meaning and value of graphic formulæ, for while chemists hold that they are simply convenient conventional methods for expressing the ascertained facts of chemistry, and true only to the extent that they express those facts, Lieutenant Bernadou appears to regard them as original sources of information.

The useful portions of this book are the translations of the papers of Vieille and of Bruley on the Nitration of Cotton, and that of Mendeléef on Pyrocollodion Smokeless Powder, though the value of the last is lessened by the omission of all reference to the source from which it is drawn, especially as the author states in the preface that these are only 'translations of certain portions of their works on explosives.' It should be understood that while translations are a convenience, one who differs from an author should not rely upon a translation, but should first consult the original publication before expressing this difference, and the translator should be willing to have this comparison of his translation readily made by giving his sources.

The record of the results of a few experiments on the solubility of cellulose nitrates at low temperatures in continuation of the work of McNab is interesting. If Lieutenant Bernadou had but multiplied these experiments and reported them in a simple manner he would have produced something more useful to mankind than the speculative essay he has chosen to present. CHARLES E. MUNROE.

Select Methods of Food Analysis. By HENRY LEFFMANN and WM. BEAM. Philadelphia, Pa., Blakiston's Son & Co.

It is stated by the authors that "this book is intended to be a concise summary of analytic methods adapted to the needs of both practicing analysts and advanced students in applied chemistry."

The first part of the work, pages up to 68, is occupied with a brief description of the principal analytic methods employed, including spectroscopy, microscopy, polarimetry, methods of determining melting and boiling points and other general operations.

In the part given to applied analyses, comprising the rest of the book, are articles devoted to general methods for the examination of poisonous metals, colors and preservatives, while under special methods are treated the processes for determining carbohydrates, fats and oils, milk and milk products, tea, coffee and cocoa, condiments and spices, alcoholic beverages and flesh foods.

An appendix contains tables of specific gravities of water, conversion tables for thermometric degrees, tables of elements, symbols, and atomic weights, and plates showing the structure of tea leaves and starches.

In regard to the analytical methods the authors say: "The bulletins of the United States Department of Agriculture (Bureau of Chemistry) and of the Association of Official Agricultural Chemists are now nearly all out of print and scarce. The present work contains a large amount of the data and processes given in those publications, together with data from reports of some of the State agricultural experiment stations."

In addition to this general acknowledgment, the articles copied directly from the above publications are credited in the text in most cases. The authors have reproduced the plates of tea leaves and starch granules of the Bureau of Chemistry, of the Department of Agriculture, stating that the originals in many cases have been retouched by Dr. Beam.

The work is illustrated with 53 figures in addition to the plates of leaves.

This work will prove of great help to analysts who do not have access to the literature of the subject or who have not the time to make their own investigations thereof. The matter is well arranged and classified and in convenient form for reference. H. W. WILEY.

The History of Medicine in the United States, etc., to the Year 1800. By FRANCIS RANDOLPH PACKARD, M.D. J. B. Lippincott Co., Philadelphia. 1901. 8vo. Pp. 542. Illustrated.

The difficulties to be encountered in writing a history of early medicine in America have hitherto deterred authors from attempting this really herculean task, and it is not surprising, therefore, that we find Dr. Packard, in this hitherto untrodden field, claiming for his work

rather the rôle of a series of essays and compilations than of a continuous historical work. The thirteen original colonies were so scattered, so remote from and so independent of each other, that each formed a community to itself, and any attempt at a general history must deal largely and directly with these separate centers. A vast amount of research must therefore be made into records, many still in manuscript, from New Hampshire to Georgia, and this would take more time and means than medical historians—whose work must always be largely, as Dr. Packard says, a labor of love—can give. It is an encouraging circumstance that these records are gradually being made known through individual research, as evidenced by papers appearing from time to time in the journals and even by more pretentious works ; and the time is probably not far distant when sufficient material will be at hand for a comprehensive historical work. But even now we can hardly feel that Dr. Packard has exhausted all readily available sources of information. In the writer's own community for example he has entirely overlooked such sources that are at his very elbow in the library of the College of Physicians and Surgeons of Philadelphia. And it is in no invidious spirit that we are led to remark that whilst Philadelphia was the chief medical metropolis of the colonies, there were other medical centers even then, and even in rural sections there were physicians of wide repute and influence whose names and records cannot be omitted from such a work. The South particularly furnished many such men educated abroad and endowed with all the learning of their day. An item of page 156 of Dr. Pepper's work would seem indeed to indicate that the physicians of the Middle and Southern States had better training than those of New England. It is there stated that of the 63 Americans who graduated in medicine at the University of Edinburgh between the years 1758 and 1788, *but one* came from the New England colonies. When we recall that Edinburgh was the chief place of resort for medical students going abroad, and that a large proportion of the 63 came from Southern States, it seems strange that this section should be comparatively so ignored by Dr. Packard. Take the state of Maryland, for example, one of the oldest and most important of the thirteen colonies. I find in the list of authorities 'chiefly consulted' by Dr. P., 67 in number, but *one* from Maryland, viz., 'McSherry's History of Maryland.' And in the 16 pages of index there are *but 13* references bearing in any way upon this state and its doctors. It would be easy to show that Maryland does not deserve this slight.

There are several errors and omissions to be noted, but we have only space for the following: At pages 11 and 12 Mr. Pratt is appointed surgeon to the plantation in 1682 and perishes in a shipwreck in 1645 (!). At page 90 vaccination is said to have been announced by Jenner in 1779. At page 432 inoculation is said to have been 'introduced' in 1712. In the copy of Dr. John Archer's diploma, the first conferred in America, page 161, there are several inexcusable errors, in one place nearly a whole line being omitted. At page 62 it is stated that the first recorded autopsy in America occurred in 1674, whereas several recorded in Maryland preceded this by about thirty years. We also know of at least two medical societies not included in the 17 stated to have existed prior to 1800. These facts could have easily been ascertained by Dr. Packard. At page 36, it is said the degree of M.D. was conferred at the University of Aberdeen in 1650, which we feel sure is a mistake. The omissions, as we have noted, are many, but surely the author should have referred to Drs. Henry Stevenson, James Smith and Gustavus Brown, of Maryland, the first maintaining for many years the only inoculating hospital in America, the second doing more perhaps for the introduction of vaccination over the United States than any other person whomsoever, the third, besides eminence in other respects, having the distinction of being called in consultation in the last illness of George Washington.

Dr. Packard has given full and graphic descriptions of the yellow fever epidemics in Philadelphia and has thrown much light on the medical development of the continental army during the Revolution. In an interesting account of the introduction of anæsthesia, he gives due credit for the discovery to Dr. Craw-

ford Long, of Georgia, who first used sulphuric ether to produce unconsciousness in surgical operations in 1842, four years before its use at the Massachusetts General Hospital.

In conclusion, if in our rôle as critic and reviewer we have said anything to make the reader think ill of Dr. Packard's book, we desire now to take it all back and to assure him that it is a most interesting and valuable contribution to American history and literature.

E. F. C.

SCIENTIFIC JOURNALS AND ARTICLES.

THE *Botanical Gazette* for October contains the following papers: F. L. Stevens publishes the third and last part of his paper entitled, 'Gametogenesis and Fertilization in *Albugo*.' A multiple fertilization was unknown before its discovery by the author in *Albugo Bliti*, the only species of *Albugo* previously investigated exhibiting simple fertilization. The present paper includes *A. Portulacæ*, *A. Tragopogonis* and a reinvestigation of *A. candida*, and shows that these species, together with *A. Bliti*, form a series differing in the prominence of the 'receptive papilla,' the development of the cœnocentrum, and in the functional egg nuclei. The conclusion is reached that the primitive forms were multinucleate, and that the uninucleate condition is a derived one. It its ontogeny *A. Tragopogonis* indicates this, its oosphere in early stages being multinucleate, and later becoming uninucleate by degeneration of supernumerary nuclei. The cœnocentrum, an organ of hitherto unknown function, is shown to serve in the nutrition of the surviving female nucleus. Many conditions are noted which tend to confirm Strasburger's theory regarding kinoplasm and its relation to sexual differentiation.

W. L. Bray completes his paper on 'The Ecological Relations of the Vegetation of Western Texas.' It is a general discussion and analysis of this interesting field, and is designed primarily to form the basis of a detailed botanical survey of the State. The author considers at some length the relation of the vegetation to the climatic factors of temperature, moisture, winds and sunlight; and to the so-called edaphic factors of physiography, soil structure and other geological phenomena. The greater part of the paper, however, is given to a discussion of the plant formations of the region under the following general heads: (1) Grass formations; (2) woody formations, including numerous types of arborescent and chaparral formations; (3) water storage formations; (4) formations of cryptogamous xerophytes; and (5) halophytic plants. The following propositions summarize the main features of the discussion: (1) The climatic conditions conspire to make the west Texas region a typical 'grass plains country'; (2) in its temperature relations the vegetation ranges from the tropical to the transition zones; (3) the region is marked by several climatic types which are enumerated; (4) the original formations are undergoing profound changes due to human agencies, the tendency being to break up the grass formations and to permit the encroachment of woody vegetation; but areas of arborescent vegetation are being denuded of valuable timber, thus forcing the question of water supply and control of floods.

Mr. James B. Dandeno points out the confused usage of physiologists in designating the solutions with which they have worked. The term 'normal solution' has been used by some for solutions containing a gram equivalent per liter of solution, by others for those containing a gram equivalent per liter of water, and by still others for gram molecule per liter solution. After defining these three carefully and calling attention to the usage of chemists, he cites examples of confused usage by physiologists, and urges that care be taken to distinguish between different sorts of solutions and to avoid misuse of the term 'normal.'

Mr. Burton E. Livingston adds to his previous contribution on the same subject an account of several lines of experimentation, which extend his previous results and confirm his conclusions already expressed. In the new experiments upon *Stigeoclonium tenue* he has used solutions of non-electrolytes (in this case sugars), and also solutions containing both sugar and mineral salts; further, he has cultivated these plants on porous plates, in gelatin, in darkness, and under conditions where evaporation would concentrate solutions. He finds in all cases that osmotic pressure is the deter-

mining factor for the form of the plant, whether the cells are immersed in solution or supported upon gelatin or upon porous plates; and as darkness has no effect upon the form of this plant, its polymorphism does not depend upon photosynthesis. His physiological experiments have been supplemented by a considerable series of physico-chemical tests in order to determine whether error had been introduced into his experiments by assumption that complete ionization occurred in his solutions of electrolytes. He finds that the osmotic pressure calculated by the freezing point method, and in some cases also by the boiling point method, conforms so closely to the osmotic pressure calculated on the assumption of complete ionization, that no error had been introduced, the differences between the calculated and determined pressures lying entirely within the range of the pressure limits found for the several responses of the plant.

T. C. Johnston publishes some results in connection with intramolecular respiration, and Dr. J. Schneck records some interesting observations on *Aquilegia Canadensis* and *A. vulgaris*.

SOCIETIES AND ACADEMIES.

AMERICAN MATHEMATICAL SOCIETY.

A REGULAR meeting of American Mathematical Society was held at Columbia University on Saturday, October 26, extending through the usual morning and afternoon sessions. The first part of the afternoon session was devoted to a joint meeting with the American Physical Society at which a paper 'On the Theory of Elastic Plates' was read by Professor J. Hadamard, the representative of the University of Paris at the recent Yale Bicentennial. About forty persons were present at the joint session, which was presided over by President Michelson, of the Physical Society. At the separate session of the Mathematical Society, at which Vice-President Thomas S. Fiske occupied the chair, thirty-three members of the Society were in attendance. Twelve persons were elected to membership: Mr. C. H. Ashton, Harvard University; Professor H. Y. Benedict, University of Texas; Dr. William Findlay, Columbia University; Dr. W. B. Fite, Cornell University; Professor G. W. Greenwood, McKendree College; Professor F. W. Hanawalt, Iowa Wesleyan University; Dr. E. V. Huntington, Harvard University; Professor H. W. Kuhn, Ohio State University; Dr. I. E. Rabinovitch, New York City; Professor W. D. Tallman, Montana State Agricultural College; Mr. H. M. Tory, McGill University; Mr. A. H. Wilson, Princeton University. Seven applications for membership were received. The By-laws of the Society were amended to provide that the presidential address shall hereafter be delivered at the last meeting of the presidential term. As the amendment takes effect at once, President Moore's address will be postponed to the annual meeting of December, 1902.

The following papers were presented at this meeting:

PROFESSOR G. A. MILLER: 'On the abelian groups which are conformal with non-abelian groups.'

DR. H. F. STECKER: 'Concerning the elliptic $\wp(g_2; g_3; z)$-functions as coordinates in a line complex, and certain related theorems.'

MISS I. M. SCHOTTENFELS: 'Generational definition of certain groups of order 960.'

PROFESSOR OTTO STOLZ: 'Zur Erklärung der Bogenlänge und des Inhaltes einer krümmen Fläche.'

DR. L. P. EISENHART: 'Conjugate rectilinear congruences.'

PROFESSOR S. E. SLOCUM: 'The symbols of the infinitesimal transformations which generate the parameter groups corresponding to all possible types of structure of two-, three- and four-parameter complex groups.'

DR. E. V. HUNTINGTON and DR. J. K. WHITTEMORE: 'Some curious properties of conics touching the line infinity at one of the circular points.'

PROFESSOR J. HADAMARD: 'On the theory of elastic plates.'

PROFESSOR E. B. VAN VLECK: 'On the zeros of fundamental integrals of regular linear differential equations of the second order, with a determination of the number of imaginary roots of the hypergeometric series.'

DR. E. J. WILCZYNSKI: 'Reciprocal systems of linear differential equations.'

DR. I. E. RABINOVITCH: 'On some contradictions involved in the elliptic geometry in a point space.'

DR. EDWARD KASNER: 'Determination of the integrals in the calculus of variations leading to an assigned system of extremals.'

The members of the two societies lunched together at the University restaurant, and in

the evening several of the members dined at Mock's restaurant in Forty-Second street. These opportunities for informal intercourse are always an enjoyable feature of the meetings. The Christmas meetings of both societies extend through the two days, Friday and Saturday, December 27–28, and it is hoped that a considerable number of the members will arrange to attend the informal dinner which will be arranged for Friday evening.

F. N. COLE,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY OF THE NEW YORK ACADEMY OF SCIENCES.

THE first meeting of the Section was held on October 21. In calling the meeting to order the chairman spoke of the loss to the Academy and to science occasioned by the deaths of Dr. T. G. White, secretary of the Section, and Professor Joseph Le Conte, corresponding member of the Academy. A committee consisting of Professors J. J. Stevenson and J. F. Kemp was appointed to draw up suitable minutes in reference to Dr. White and Professor Le Conte. Dr. E. O. Hovey, of the American Museum of Natural History, was then elected secretary of the Section.

The following program was offered : Dr. A. W. Grabau spoke on 'Recent Contributions to the Problem of Niagara.' He said that Davis has shown that the topography of the Niagara region conforms to the type generally found in ancient coastal plains, the original features of which have been more or less modified by subsequent warpings, and by glacial erosion and deposition.

The Niagara escarpment is the inface of the Niagara cuesta, traceable through the Indian Peninsula and Grand Manitoulin Island. The Ontario lowland is continued in the Georgian Bay lowland. A second cuesta—the Onondaga—has its inface slightly developed north of Buffalo, but becomes prominent in the Lake Huron valley, where its inner lowland forms the deeper part of the lake. The third cuesta and lowland (the Erie) occurs north of the second.

The Tertiary drainage is supposed to have been to the southwest, instead of the northeast, as Spencer holds. The principal streams of that time are supposed to have been (1) the Saginaw, whose path is indicated in part by Saginaw Bay and the deep channel between the Indian Peninsula and Grand Manitoulin Island ; (2) the Dundas, breaching the Niagara cuesta at Hamilton, Ont., and crossing the Erie lowland near Fort Stanley ; and (3) for a time, at least, the Genesee, though this may later have had a northward course. The subsequent streams tributary to these consequents carved the various lowlands. St. Davids channel is regarded as an obsequent stream, which was accidentally discovered by the Niagara. The whirlpool gorge was probably, in part, the southward continuation of this stream, and not wholly postglacial.

Professor J. F. Kemp's first paper was on the 'New Asbestos Region in Northern Vermont.'* He said that asbestos has recently opened up on a commercial scale in the towns of Eden, Lamoille Co., and Lowell, Orleans Co., Vt. The towns are adjacent, although in different counties. The asbestos lies from 15 to 25 miles north of Hyde Park, a station on the St. Johnsbury and Lake Champlain R. R. As is quite invariably the case, it occurs in serpentine, either in veins or in matted aggregates along slicken-sided blocks. The serpentine where the best fiber is found lies on the south shoulder of Belvedere Mountain, and forms an east and west belt. It is bounded on the north and west by hornblende-schist, which forms the summit of the mountain. The contact on the west is a visibly faulted one, and that on the north is probably also of the same sort, because the hornblende-schist rises in a steep escarpment.

The serpentine seems to have been derived from enstatite, diallage and probably olivine, since unaltered nuclei of these minerals are found in it. The vein asbestos ranges from a fiber of microscopic length up to $\frac{3}{4}$ of an inch as thus far exposed. It is fine and silky and of excellent grade. It would, however, be classed as second grade according to the Canadian practice, which makes a first grade, of fiber above $\frac{3}{4}$ of an inch (about $2\frac{1}{2}$ in. being the maximum), and a second grade of $\frac{3}{8}$ in. to $\frac{3}{4}$

*Communicated by permission of the Director of the U. S. Geological Survey.

in. All below this and all fiber not vein fiber goes to the mill and is mechanically separated, as the third grade. In the Vermont localities the slip fiber is exposed on the property of the New England Co., and of its neighbor, the American Co. The vein fiber is limited, so far as yet opened up, to the property of Mr. M. E. Tucker and associates.

It is difficult, with the data in hand, which were gathered under the direction of Dr. C. W. Hayes, of the U. S. Geological Survey, to trace the geological history of the serpentine, but it must have been originally either an igneous pyroxenite or peridotite or else a richly magnesian siliceous limestone. There are such slight traces of calcium-bearing minerals, however, that the former supposition has the greater weight. The hornblende-schist consists in largest part of common green hornblende but one may also observe epidote, zoisite and some minor accessories.

Professor Kemp also gave a paper on the 'Physiography of Lake George.' The observations, extending over several years, have suggested the following conclusions: Lake George occupies a submerged valley very similar to many others in the Adirondacks which are not submerged. The valley has been largely produced by faulting, and the fault-scarps still remain in precipitous cliffs, whose sharpness has not been much affected by weathering and erosion. Before the Pleistocene the valley was probably a low pass with both a north and a south discharge. The portion rich in islands near Pearl Point and the Hundred Island House was probably the divide, and the islands represent the old hillocks near the top of the divide. At the south the water is backed up by sands and morainal matter in the valleys on each side of French Mountain, viz., at the head of Kattskill Bay and at Caldwell. On the north they are held in by Champlain clays and syenitic gneiss at the Ticonderoga outlet, and probably by morainal material at the low pass just south of Rogers Rock and leading out to the very depressed Trout brook valley, just west of Rogers Rock and Cook mountains. Trout brook is now as much as a hundred feet lower than Lake George at points south of the Ticonderoga barrier. The northern barrier is rock, because the Ticonderoga river passes through a narrow and shallow channel in the exposed ledges a mile south of its actual first waterfall. There is here a broad flat valley buried in clays, however, beneath which an old channel may lie submerged. At the same time the marked depth of the Trout brook valley to the west makes this the natural outlet, and there is reason to believe from the general topography that the discharge passed north into the Champlain valley near the south boundary of Crown Point. It is also not to be overlooked that a valley with much drift leads eastward to Lake Champlain, from the head of Mason's Bay.

A curious feature that is common to both shores of the lake north of Sabbath Day Point (and perhaps also south of it) is the presence of pot holes of great perfection and as high at times as 30 feet above the present level of the lake. These are best developed on Indian Kettles Point, about two miles north of Hague. They were doubtless excavated by lateral or subglacial streams when the ice filled the lake valley, because in no other conceivable way could flowing water be forced into such unnatural situations.

There is great need of a good hydrographic survey of the lake, and of detailed pilot charts, with soundings. They would be of great service, not alone to navigators, but to science as well. So far as could be learned from local fishermen, whose deep trolling for lake trout gives them familiarity with the bottom, there appear to be channels whose general trend is parallel with the long dimension of the lake, and which have precipitous sides, precisely like the valleys and gulches now visible. The lake is relatively shallow as compared with Lake Champlain. In Lake George, the greatest depth is believed to be near Anthony's Nose, and to reach 190 feet. Elsewhere the deep parts are placed at about 100 feet, more or less. All this, however, requires confirmation by soundings. With regard to the physiography of the bottom one cannot say to what extent the valley has been filled by drift, but the islands to which physiographic importance has here been given are rock.

Richard E. Dodge,
Secretary pro tem.

BOTANICAL SEMINAR OF THE UNIVERSITY OF NEBRASKA.

AT the regular meeting on November 1, Dr. Roscoe Pound read a paper on 'The Purpose and Force of Botanical Laws,' directing attention to the fact that rules of procedure in science are as necessary as they are in civil life, and indicating that the method by which laws are obtained in the one case must be similar to those in the other. The paper was discussed by Professor Bessey (who spoke of the supposed danger of a repression of originality through the action of laws of science); Dr. Wolcott (who called attention to the code of laws and their successful execution in ornithology); and Dr. Clements (who discussed a proposed series of regulations in regard to the nomenclature of plant geography).

DISCUSSION AND CORRESPONDENCE.

PREGLACIAL DRAINAGE IN SOUTHWESTERN OHIO.

TO THE EDITOR OF SCIENCE: In the issue of SCIENCE of October 4, Professor Arthur M. Miller offers an objection to the conclusions of Mr. Fowke, made from his studies on the drainage features of southwestern Ohio, in which Mr. Fowke has shown (*Bulletin of the Scientific Laboratories of Denison University* and *Special Paper No. 3 of the Ohio State Academy of Science*) that the preglacial drainage of the section of the Ohio river from Manchester, Ohio, to Madison, Ind., was to the northward along the line of the lower Big Miami and the Mill creek valleys to Hamilton. It has been my pleasure to have studied somewhat carefully the region under discussion in my field work, and the objections which seem so apparent to Professor Miller have not appeared so to me. While I would agree in the main with Professor Miller in his argument concerning the formation of reentrants made by up-stream cutting against an escarpment and the stratigraphic relations of stream gradient and dip, under which similar reentrants would be formed by streams flowing in the direction of the dip, I cannot see that there is much force in the application of these principles to the problem under discussion. There is no question but that many of the reentrants found in the Clinton limestone outcrop of the region shown by Professor Miller's map were made in the manner he suggests. I have observed many of them in the field. But at the same time there are many possibilities of there being, in this same region, large valleys deeply buried under the mantle of drift running in the opposite direction from that of these reentrants which were formed by the backward-cutting streams. In all cases which I have observed of these reentrants made by backward-cutting streams, they might have as well formed part of a system of lateral tributaries to a main northward-flowing stream as to that of a southward-flowing one. Unfortunately the region which Professor Miller has chosen in his map and studies is not the same as that which furnished the data for the determination of the northward direction of the preglacial waters from the vicinity of Cincinnati and it would be hardly necessary to review these data at this time, as the full reports are easily accessible in the articles referred to and are not discussed by Professor Miller. It may be well to state, however, that the criteria used in the location of the preglacial lines of drainage are not confined to a study of comparative 'width-of-channel' of streams, but the conclusions are based upon a broader study of topographic forms, comparative erosion, distribution and direction of shingling of old gravels on the old graded valley floors, normal and abnormal stream relations and many other similar lines of evidence.

In Professor Miller's closing paragraph he speaks of the symmetry shown by the streams north and south of the Ohio river as adding force to the argument in favor of the present arrangement of the streams being also the preglacial arrangement, and he considers the Ohio as the main and parent stream. There seems to be an abundance of evidence, already published, to show that in preglacial times a strong watershed crossed the Ohio river near Manchester, Ohio, and that the section of the Ohio immediately above Manchester found its way up the reversed Scioto in preglacial times. With the Ohio river above Cincinnati reduced to a small stream (which Mr. Fowke calls Old Limestone) heading only at Manchester, it

is evident that the Miami, Licking and Kentucky rivers were all very much larger streams than Old Limestone, and if we should assume that the section of the Ohio below Cincinnati flowed, in preglacial times, in its present direction, the symmetry which Professor Miller sees in the present arrangement would appear most asymmetric.

I feel sure that a careful field study of the topographic features within a radius of twenty miles from the city of Cincinnati will convince any one of the truthfulness of Mr. Fowke's deductions.

W. G. TIGHT.

UNIVERSITY OF NEW MEXICO.

PERMANENT SKIN DECORATION.

THE July-December, 1900, issue of the *Journal of the Anthropological Institute* publishes an abstract (No. 117) of Mr. H. Ling Roth's article 'On Permanent Artificial Skin Marks, a Definition of Terms.' The author distinguishes four varieties, all collectively and rather loosely designated by travelers 'tattooing.'

I. The Tahitian punctured method—practiced also by sailors, soldiers, etc.—by which a design is pricked into the cuticle, leaving a smooth even surface of skin.

II. The Maori chiseled type, produced by an adz-like implement, in addition to the Tahitian pricker, and exhibiting when completed a fine pigmented groove.

III. The West African incised variety—usually, but not always, non-pigmented—wherein deeper and wider grooves are cut—*not tapped*—with a knife, bone or hardwood chisel.

IV. The raised scar ('cicatrice saillante') of Tasmanians, Australians, Central Africans, etc., resulting from the continued irritation of the original incision, the insertion of foreign matter and the over-production of reparative tissue lifting the design in welts.

Mr. Ling Roth considers it desirable that the Tahitian word 'tatu' be confined to the first-named process, the native designation 'moko' be recognized for the second; for the third and fourth respectively, the terms cicatrix and keloid are offered.

This classification, looking toward greater precision in the use of descriptive epithets, is avowedly based chiefly on the character of the implements used and the method of their employment. The author has, however, overlooked two types as well marked as any of those included, the Dayak and the Eskimo. The former make use of a wooden block upon which the desired pattern is figured in relief. It is transferred to the skin by percussion, the block being pounded with an iron bar. Regarded from the side of its probable descent, this method must be deemed a subvariety of II. Classed by the tool producing it, it forms a distinct variety.

The other and more important omission, the inductive or line tattooing of the Eskimo seems most nearly related to type I, the latter form indeed occurring side by side with it. In the central regions, according to Dr. Boas, a needle and thread covered with soot is passed under the skin, the point of the instrument also being rubbed with a mixture of the juice of *Fucus* and soot or gunpowder. ('Central Eskimo,' p. 561.) The two processes recur more or less intimately associated over the greater part of the Eskimo habitat. The writer of this note would suggest for this inductive variety (type V.) the use of the Central Eskimo word 'kakina' (pronounced kakeena)='tattoo marks,' a term derived from the verb 'kakiva'='pierces it,' as in sewing, so as to make the point appear again on the same side. (See Rink, 'Eskimo Tribes,' p. 117.)

The main objection to the differentiation of these two types (II. b and V.) is the difficulty of distinguishing between II. a and II b, and between I. and V., when neither the operation nor the implement has been observed.

H. NEWELL WARDLE.

ACADEMY OF NATURAL SCIENCES,
PHILADELPHIA, PA.

MAGAZINE ENTOMOLOGY.

TO THE EDITOR OF SCIENCE: Columns open for attack have surely room for defense—wherefore permit me to say to the critical Mr. Smith, of New Brunswick, that I fear he does not quite understand the article he criticises. The paper in *McClure's* for September is part of a book not meant in the least to be scientific, entomologic, or any other 'ologic, but simply to set down things seen, and heard, and done, by two

fairly intelligent young people, living next to the ground upon a plantation in middle Tennessee.

Now as to hellgramites—the name may not properly apply to the white grubs, or rather, grayish-white ones, which were the choicest of all bait. But local fishermen called them so, and accepted it as a matter of fact that they were larvæ of the dragon-fly. Since I was setting down things actually true of a certain limited scope, not discoursing, *ex cathedra*, upon entomology, I felt justified in putting down the local name—with no thought of *lèse majesté* against the hellgramite and his adherents. I thought if my work was to have the value of verity I must make it square with what I knew, rather than the word, the latest word, of science. I fancy if explorers—say Stanley or Baldwin—came out of strange places, recording that the popular beliefs there were consonant with the newest discoveries, their work would have less worth and gain less currency. However, that has nothing to do with this particular case. Explorers are fallible persons—almost as fallible as myself. The only infallibles are those aggrieved persons who are always trying their cases in the newspapers.

Wherefore it is with something of amazement that I read Mr. Smith's positive assertion: "Pithy stems are rarely used by locusts, if at all, and dying twigs are never attacked." Will he kindly tell me, if pithy stems are never used, what sort are? No twig or stalk within my knowledge is, in its early stages of growth, without pith. In woody plants, after the wood ripens the pith becomes a fine line, and as the twig develops into a bough, wellnigh invisible. But assuredly if there is a deciduous tree whose new growth is not, while new, pithy, I have never seen nor heard of it. And at the risk of seeming more than ever contumacious, I repeat that some locusts—Tennessee locusts—did choose dying twigs to lay their eggs in—I watched them do it through many a summer hour, in the big oak whose bough almost touched my upstairs window. The twigs were of new wood—the last spring's growth—but yellowing, and beginning to wither. I do not recall ever seeing a sound twig stung by the ovipositor. The locust, or rather the female locust, has two fine saws, lying either side the ovipositor. With these saws she scratches the bark before depositing the egg. As to Betty-bugs three inches long—they are facts, not fiction. A Mississippi reader has just written, promising to send me one of them next season. He adds the interesting information that when one of the big Bettys falls upside down, one can see upon its under side a number of parasites. Regarding the June bug's identity, that was a matter of countryside belief, backed with pretty good olfactory proof of the transformation. And certainly plenty of true June bugs, green above, all yellow underneath, mingled amicably enough in the flights and hummings of the tumble bugs, black and green.

Let me say further—of the magazine articles, and the whole book—that my aim was not to instruct, but to record a phase of life known to me at first hand. Mr. Smith and the gentlemen of his kidney who assume that whatever is outside their own experience is necessarily false, have, without intending it, done me a real service, by showing me that before the book appears I must so elaborate its *motif*, and make it so glaring, and obvious, that even a wayfaring man, almost an infallible one, if he reads at all, will be forced to read aright.

MARTHA MCCULLOCH-WILLIAMS.

Very little comment on the above is really necessary. If Mrs. Williams is giving records of superstitions and country beliefs she owes it to her readers, as well as herself, to make it perfectly clear that this is the case, and that they are not intended to be received as instruction or as statements of fact. I am unable to see the bearing of some of Mrs. Williams's references to Stanley, etc., but that I presume is due to my own obtuseness. So I did not dream that an oak twig could ever be called 'pithy.' If the explanation were not made by a lady I should call it quibbling. It is a real pleasure to me to realize that I have done Mrs. Williams a favor, and I hope it will inure to the benefit of the readers of her forthcoming book. It is of course adding another to my sins; but I cannot refrain from saying that no insect to which the name 'locust' was ever justly applied in any publication known to me, has 'two

ne saws, lying either side of the ovipositor.' Nor, if a cicada is referred to, does the description of the method of oviposition accord with the fact. Finally, it might be desirable for Mrs. Williams to get the real facts concerning honey bees, that the rate of her 'fair intelligence' in middle Tennessee be not fixed unjustly low.

J. B. S.

CURRENT NOTES ON PHYSIOGRAPHY.

THE HIGH PLAINS OF COLORADO, KANSAS AND TEXAS.

THE attractions of the diversified Cordilleran region have caused the relative neglect by the geologist and the geographer of the more monotonous area of the Great plains during the last thirty years of exploration. Following the recent increase of attention to this extensive area, we now have an admirably lucid report on 'The High Plains and their Utilization,' by W. D. Johnson (21st Ann. Rep. U. S. Geol. Surv., pt. IV., 1901, 601–768, many excellent plates and figures), giving description and explanation to a stretch of the highest and smoothest part of the Plains, from 150 to 200 miles east of the mountains, in Colorado, Kansas, Texas and New Mexico. The largest continuous area here included is that of the Staked plains, between the Canadian and Pecos rivers, but more attention is given to certain smaller areas, separated by successive west-east valleys and extending through Kansas and Colorado northward towards Platte River. The strata of the High plains are chiefly silts, irregularly interstratified with gravel and sand in linear arrangement, but in lines slightly divergent and crossing. Silt is the most abundant material, yet coarser deposits are so plentiful that the whole loose accumulation is sometimes referred to as the 'Tertiary gravel.' This extensive deposit, in some places 500 feet thick, is the product of aggradation by braided or laced streams, whose load of material from the mountains could not all be carried across the gentle slope of the Plains. Evidence of this origin is found not only in variable composition and irregular stratification, but also in the trains of well-rounded gravel, derived from the resistant rocks of the mountains, stretching forward with the slope of the Plains, and becoming finer textured eastward. The lacustrine origin of these strata, usually advocated heretofore, but discountenanced by Gilbert and Haworth, is considered by Johnson and again rejected on good grounds. The fluviatile deposits mantle an uneven surface of older rock, eroded by an ancestral drainage system. They originally formed a vast 'débris-apron' of numerous laterally confluent river fans of long radius, with continuous slope eastward from the mountain base. The region was then a fluviatile plain of great dimensions, similar to that which to-day stretches southward from the base of the Himalayas, in northern India, and similar to the extensive piedmont fluviatile plains of mountain waste that are so commonly and appropriately associated with great mountain ranges in one or another phase of their maturity. But the High plains are now trenched by the west-east valleys worn by the successors of the streams that built the plains; this being the result of some change (preferably the increase of rainfall that accompanied the glacial period) whereby the capacity of the streams to erode was restored. Moreover, the fluviatile mantle has been worn away along two north and south belts. One is the arid belt near the mountain base, where vegetation is so scanty that the small rainfall has sufficed to wear away much of the river-made strata in the excavation of lateral valleys. The other belt begins 100 or 200 miles further east, where the rainfall is heavier and where the headward (westward) growth of many streams is pushing back a badland escarpment. Between these two degraded belts the tattered remnants of High-plains mantle are still smooth and uncut, because under their subhumid climate they have a close-knit cover of sod which has held fast under their light rainfall.

The dead-flat upland of the High plains is lightly pitted here and there by shallow circular depressions, up to 1,000 yards across. These hollows are not due to wind action, for however dusty the gales may be on the arid belt further west, the winds blow clear on the sodded plains. Some of the hollows are crater-like; many are encircled by cracks and rims of slightly settled grounds, and all except the small 'buffalo wallows' are regarded as sinks

due to some action of underground water. Being out of the reach of irrigation from the rivers, and not having enough rainfall for agriculture, the utilization of the High plains must be chiefly as cattle ranges for which water may be gained by wells and windmills.

SOUTH SHORE OF HUDSON STRAIT.

THE forbidding character of a rocky upland that has been recently and severely glaciated and that still possesses a severe climate is well portrayed in Low's 'Report on an Exploration of Part of the South Shore of Hudson Strait * * *' (Geol. Surv. Canada, Ann. Rep., XI., 1901, L.): "The rocks met with are all of great antiquity, and all are more or less altered by pressure, induced by intrusions of igneous masses which have folded the bedded series and have produced foliation in much of the otherwise massive granites, gabbros," etc. (p. 31 L.). The crystalline rocks usually form a highland which reaches altitudes between 1,000 and 2,000 feet near the sea, and is often plateau-like in the extent of its rolling uplands between deep and sharp-cut valleys or canyons. Here rock and boulders are abundant and soil is very scanty; here are abundant lichens and some flowering plants, but no trees. Elsewhere the rocks are stratified and gently inclined, forming low ridges with steep outcrop faces and gentle back slopes. Below 300 feet the surface is generally mantled with marine clays, marked with terraces. But as the land rose from its postglacial submergence, the headlands "have been smoothed and polished by the pounding of floating ice, which has removed nearly all the drift from the points, leaving the solid fresh rock always exposed."

THE ORIGIN OF WATERFALLS.

THE 'Festschrift des Geographischen Seminars der Universität Breslau zur Begrüssung des XIII. Deutschen Geographentages' contains, among various essays, most of which turn toward historical geography, an article on the Origin of Waterfalls, by F. Sturm (pp. 122–132, Breslau, 1901). Besides the numerous rapids and falls which originate at points where a young stream passes from a more to a less resistant rock, or where a new course has been taken in consequence of drift barriers, a number of special cases are instanced, such as rapids in a main stream where side streams form boulder dams, illustrated by the Colorado in its canyon; rapids occurring where travertine is deposited in a stream channel, as illustrated at several points in Bosnia, and falls over fault escarpments, such as those of the Oxara in Iceland. The order in which different kinds of falls are presented is empirical rather than genetic.

Falls at the mouths of hanging valleys are explained as resulting from the faster erosion of the main than of the side stream; strong glacial erosion of the main valleys in excess of that in the side valley is discredited. It is not noted in this connection that hanging side valleys with falls leaping from their mouths into broad-floored main valleys are known only in glaciated districts; and that in non-glaciated areas, side streams 'hang' above their masters only in the earliest stage of a new cycle; accordant junction of side and main stream being developed about as soon as the main stream has graded its channel, and long before it has broadly opened its valley floor.

W. M. DAVIS.

CURRENT NOTES ON METEOROLOGY.

METEOROLOGICAL EQUIPMENT OF THE 'DISCOVERY.'

THE meteorological equipment of the British Antarctic exploring vessel *Discovery* is described by Dr. H. R. Mill in *Symons's Meteorological Magazine* for September. The Stevenson screen contains a wet and dry bulb thermometer, a mercurial maximum, and a Six's maximum and minimum thermometer. A barometer, on the Kew pattern, is in the magnetic house, and a barograph is kept in one of the companions. A thermograph and a hair hygrograph are placed on the outer wall of the magnetic house. The three recording instruments are kept running to Greenwich time. The temperature readings are checked by means of an Assmann Aspiration Psychrometer, and sling thermometers are also provided for comparison. Rainfall observations are to be made with a marine rain-gauge and evaporator of Dr. Black's pattern. For carrying out observations in the free air, a captive balloon is carried, and kites

are to be used for greater elevations. Meteorographs after the Blue Hill pattern are to be sent up with the kites. Spirit thermometers, for dry and minimum readings, graduated to —90° F.; special screens; low-reading thermographs; sunshine recorders adapted to the peculiar conditions which are to be met with in the high latitudes; earth thermometers, etc.—are also provided. A Dines pressure anemometer and an anemograph of similar pattern are to be used at land station on the Antarctic continent.

CHARLES MELDRUM.

THE death, on August 28 last, of Dr. Charles Meldrum, for many years director of the Royal Alfred Observatory, Mauritius, should not be passed by without at least a brief mention in these Notes. Dr. Meldrum did a work of the greatest importance for meteorology in connection with the cyclones of the Indian Ocean, to the study of which he devoted a large part of his life. His name will also always be associated with the question of the relation of sunspots and rainfall, a subject in which he was much interested. Dr. Meldrum was one of the founders of the Meteorological Society of Mauritius, Government Meteorological Observer, Director of the Royal Alfred Observatory, and, during the last ten years of his life, a member of the Government Council of Mauritius.

BIBLIOGRAPHY.

THE annual bibliographical number of the *Annales de Géographie* (No. 10, for the year 1900) contains the usual notices of climatological publications bearing the date 1900. The reviews are arranged by subjects as well as by countries, and there is an author and a subject index. This bibliography is chiefly geographcial, but climatology is given its proper share of attention. R. DeC. Ward.

HARVARD UNIVERSITY.

SCIENTIFIC NOTES AND NEWS.

THE Elisha Kent Kane Medal of the Geographical Society of Philadelphia has been presented to Dr. A. Donaldson Smith, the African explorer.

PROFESSOR E. RAY LANKESTER has been elected a corresponding member of the Göttingen Society of Sciences.

DR. RICHARD P. STRONG has been appointed director of the Government Biological Laboratory recently established in Manila.

SIR WILLIAM WHITE, since 1885 director of naval construction in the British Navy and the author of important publications on naval architecture, is about to resign.

IT is said that Dr. Wolf Becher, of Berlin, is preparing a biography of Professor Rudolf Virchow.

A LECTURESHIP in moral science will be established at Cambridge University as a memorial to the late Professor Sidgwick. The sum of £2,450 has been subscribed for this purpose.

A DIFFICULTY has arisen, says *Nature*, concerning the site on which the new Pasteur statue in Paris shall be erected. The use of a space in the Square Médicis in the Quartier Latin has been granted, but this spot is being tunneled for a railway, and it is feared, in consequence, that the statue may be too weighty for it. Other places, such as the Place du Panthéon, the Place de la Sorbonne and the entrance of the Avenue de l'Observatoire, are under consideration.

CHARLES A. BACON, professor of astronomy at Beloit College and director of the Smith Observatory, died on November 6, aged forty-one years.

PROFESSOR M. MAERCKER, director of the agricultural experiment station at Halle, Germany, and professor of agricultural chemistry in the Agricultural Institute, died on October 19, 1901.

THE preliminary plans have been accepted for a new building for the Department of Agriculture at Washington. These plans contemplate a magnificent marble structure of classic design, something over 300 feet long, with wings at either end extending to the rear to accommodate the various laboratories of the department. It is expected that the details of interior arrangement will need to be changed to some extent to suit the needs of the various bureaus and divisions of the department, but these plans will serve as a working basis. About 158,400 square feet of space are provided. Lord & Hewlett, of New York, are the architects.

THE American Morphological Society will meet in Chicago in affiliation with the American

Society of Naturalists, beginning on Wednesday, January 1.

THE American Psychological Association has fixed the first day of its Chicago meeting for December 31. The Western Philosophical Association will this year meet in conjunction with the American Psychological Association. Professor Josiah Royce, of Harvard University, is president of the Psychological Association, and Professor Frank Thilly, of the University of Missouri, is president of the Philosophical Association.

THE Society for Plant Morphology and Physiology will hold its fifth annual meeting at Columbia University, New York City, on December 31 and January 1 and 2.

THE Association of American Agricultural Colleges and Experiment Stations meets in Washington on November 12, 13 and 14. It will be followed by the meeting of the Association of Official Agricultural Chemists on November 15, 16, and 18.

THE sixth celebration of Founder's Day at the Carnegie Institute, Pittsburgh, took place on November 7. The principal speaker was Ex-President Grover Cleveland. The occasion was made memorable by the opening of the Sixth International Exhibition of Contemporary Paintings and by the display of a larger number of new exhibits in the Carnegie Museum. Among the latter are the skeleton of *Titanotherium*, and portions of the skeleton of *Diplodocus Carnegii*, recently restored under the care of Professor J. B. Hatcher, a fine specimen of *Rhinoceros simus* Burchell, a collection of petroglyphs from western Pennsylvania, an arge additions to the collections of mammals and birds, as well a long array of exhibits in other departments of the Museum.

MR. C. W. GILMORE, who has been employed during the past summer in continuing the excavation at Camp Carnegie, on Sheep Creek, Wyoming, begun two years ago by the Carnegie Museum, completed his work last week. A carload of fossils, consisting principally of the remains of a very large and perfect specimen of *Brontosaurus* has been shipped to Pittsburgh and will shortly be delivered at the Museum.

THE collection of land, marine and fresh-water shells, belonging to the estate of the late W. D. Hartman, M.D., of West Chester, Pa., has been purchased by the Carnegie Museum in Pittsburgh. Over nine thousand species are represented in the collection, which contains many types and cotypes. It is particularly rich in North American species and in the species found on the islands of the Southern Pacific. The addition of the Hartman collection to the other conchological collections which have in recent years been secured by the Carnegie Museum gives this institution one of the largest assemblages of conchylia in the United States.

IN September the Wisconsin Natural History Society sent two expeditions to the neighborhood of the Fox River in Waukesha County for the purpose of making surface surveys of a number of still unrecorded mound groups which are liable to be destroyed when the land is put under cultivation as is to be done next year. The first expedition surveyed and plotted four groups and several isolated works in the vicinity of Big Bend. One of them is indicated on Dr. Laphan's map, but no description is given by him. The second expedition was sent to the neighborhood of Mukwanago, about four miles from the first party. It surveyed a number of burial and oblong mounds. Nearly all the burial mounds were found to have been disturbed by farmers and others living in the region.

THE Russian Imperial Geographical Society has received news from the Kozloff expedition, sent out to explore the headwaters of the Hoang River. It is said that valuable collections have been obtained.

A COPENHAGEN despatch says that Dr. Nansen, the Arctic explorer, is arranging for biological research in northern waters; Norway, Sweden, Denmark, England, Holland, Russia and Germany to take part in it. The Danish Government has resolved to invite the interested states to hold a conference at Copenhagen to discuss the subject.

THE Twentieth Century Club of Boston has arranged for six lectures on 'The Needs of Popular Education in the United States.' The opening lecture was delivered by President Eliot, of

Harvard University, on November 9, with a general introduction and survey. The succeeding lectures will be as follows: 'The Public School System,' Dr. William DeWitt Hyde, president of Bowdoin College, November 16; 'Supplementary Educational Agencies,' Dr. George Harris, president of Amherst College, November 23; 'The Place of Industrial and Technical Training in Popular Education,' Dr. Henry S. Pritchett, president of the Massachusetts Institute of Technology, December 7; 'The Place and Function of Science in Popular Education,' Dr. Ira Remsen, president of Johns Hopkins University, December 14; 'Comparison of American and Foreign Systems of Popular Education,' Dr. G. Stanley Hall, president of Clark University, December 21.

The National Geographic Society has issued its program of lecture courses for the coming season. The popular course consisting of thirteen lectures will be delivered in the National Rifles Armory, on Friday evenings at 8 o'clock, commencing November 8, and alternating with the Technical Meetings which will be held in the Assembly Hall of Cosmos Club. The following dates have been definitely assigned:

November 8, 'The Twelfth Census,' Honorable Frederick H. Wines, Assistant Director of the Census.

November 22, 'The Interior of Borneo,' Professor A. C. Haddon, Cambridge University.

December 6, 'Peary's Progress toward the Pole,' Herbert L. Bridgman, Vice-President Arctic Club of America.

December 20, 'The Trans-Siberian Railway,' Honorable E. J. Hill.

January 3, 'The New Mexico,' Honorable John W. Foster, Ex-Secretary of State.

January 17, 'American Progress and Prospects in the Philippines,' General A. W. Greely, Chief Signal Officer, U. S. A.

Arrangements have also been made for the following popular lectures, at dates to be announced later.

'The Appalachian Forest Reserve,' Honorable James Wilson, Secretary of Agriculture.

'The Warship and its Work,' Rear-Admiral W. S. Schley.

'Fifty Years of Immigration,' Honorable E. F. McSweeney, Asst. Com. Immigration.

'Cliff Dwellings of Mesa Verde,' Mrs. John Hays Hammond.

'Explorations in New York City,' Mr. Jacob A. Riis.

'Finland,' Mr. George Kennan.

Provisional arrangements have been made for lectures on Pacific Cables, Actual and Proposed; Our Coming Oceanic Canal; America before the Advent of Man; Chinese Problems; Lands and Life in Ocean Depths; Columbia; Danish West Indies, and Afghanistan—the Buffer State. Regular meetings of the Society for the reading of technical papers and discussions will be held in the Assembly Hall of Cosmos Club on Friday evenings, at 8 o'clock, and alternating with the popular lectures. The following are announced:

November 1, 'Symposium on the Growth and Prospects of the Society,' President A. Graham Bell followed by Professor Heilprin and others.

November 15, 'The Lost Boundary of Texas,' Marcus Baker, Cartographer, U. S. Geological Survey.

November 29, 'The Best Isthmian Canal Route,' Arthur P. Davis, Chief Hydrographer, Isthmian Canal Commission.

The Christmas course of six lectures to young people, at the Royal Institution, will this winter be delivered by Professor J. A. Fleming, F.R.S., professor of electrical engineering in University College, London. His subject is 'Waves and Ripples in Water, Air and Ether.' Sir H. Trueman Wood will deliver the next Christmas Juvenile Lectures at the Society of Arts, the subject being 'Photography and its Applications.'

A statement concerning the vital statistics of the city of Havana for the month of September, 1901, compiled from official reports on file in the division of insular affairs of the War Department and abstracted in the daily papers, shows that the health conditions were decidedly the best attained in any month. The least number of deaths occurring in any previous September since 1889 was 496 in 1899; the greatest number, 2,397, in 1898; average, 877. For September, 1901, there were 339 deaths. The least number of deaths occurring in any one preceding month during the last eleven years was in February, 1901, when there were 408 deaths. The lowest death rate for Sep-

tember in the years referred to was in 1899, when the death rate was 34.48 per thousand. For September, 1901, the death rate was 15.64 per thousand. Taking the yellow fever year as commencing April 1, the record of the past eleven years shows that for the six months up to the first of October the smallest number of deaths from this disease occurred in 1899, when there were 36 deaths; the greatest number in 1897, when there were 659 deaths—average, 296 deaths. This year, during the same period, there were only five deaths.

SIR CLEMENTS A. MARKHAM, president of the Royal Geographical Society, has given out for publication a communication stating that despatches received from the Cape give details of the voyage of the *Discovery* and announce the departure of the Antarctic expedition from Simon's Bay on October 14 on the voyage to Lyttelton, the last port of call before entering the ice. Experience of the performances of the ship has been acquired during a voyage of 58 days—33 under steam and 25 under sail. She might make a reasonably good passage under sail with a fair wind, but she makes excessive leeway when close hauled; her canvas area is too small, and she must be accounted a poor sailer. She is, however, an excellent sea boat, which is the main point, and in a fresh breeze with a heavy sea she is very stiff and dry. She has, on the whole, done as well as can be expected for a vessel of her type. Her coal consumption is, however, disappointing. The economy of the engines is less than expected, and the necessity for nursing coal in future operations is proportionately increased. Officers and men have had a very trying time in the tropics. The ship leaked, from causes which can no doubt be obviated. But as the provision cases were stowed in the holds down to the keelson and the water rose amongst them it was necessary to clear the holds, to construct floors with an amply sufficient bilge space beneath and to restore the holds again—all this under a tropical sun. The engineering department had still more severe work, owing to the long spell of steaming with the thermometer at 140° F. in the engine-room, and the engines, being new, required more than ordinary care and adjustment.

UNIVERSITY AND EDUCATIONAL NEWS.

THE council of New York University has decided to celebrate the seventy-fifth anniversary of the founding of the University in October, 1905. An effort will be made to collect $2,000,000 for an endowment fund.

DR. OSLER, of the John Hopkins University, has given to the medical library of McGill University a number of rare books on medicine. The medical library has been much improved in the alterations of the building.

THE Library of the Chemical Department of the University of Vermont has just been augmented by the addition of some 400 volumes, chiefly German chemical journals. These are mainly the gift of F. W. Ayer, of New York, who subscribed $1,000 to the special fund.

IT is announced that Andrew Carnegie will give $500,000 to build and equip a technical college in southern Scotland. The institution will probably be located at Galashiels, counties of Roxburgh and Selkirk.

THE widow of the late professor of the history of medicine at Vienna, Dr. Puschmann, has bequeathed her entire property, about a quarter of a million dollars, to the University of Leipsic.

THE Liverpool City Council has unanimously resolved to make application to Parliament for powers to enable the council to contribute money from the rates toward the formation and maintenance of a university in the city.

BEGINNING with the academic year 1905–06 all students desiring to enter the first year of the medical course of the University of California, and all new students seeking advanced standing must present evidence of having completed at least two full years of preliminary training in the undergraduate department of a college or university of recognized standing. Satisfactory evidence must also be presented that during these two years the applicant has completed courses in chemistry (12 hours for a year), physics (13 hours), biology (6 hours), and has a reading knowledge of French and German.

THE new chemical laboratory of the University of Oregon, for which appropriations

were made during the last two sessions of the Legislature, has been completed and equipped, and is now occupied by the department of chemistry. The building is a three-story brick structure, finished with Roman cement, and is 100 feet long by 46 feet deep. It contains sixteen rooms, of which thirteen are now in use. Four large laboratories are for student use, and will accommodate over 200 students working in sections. The lecture room has a seating capacity of one hundred and fifteen persons; it is completely equipped with separate preparation room, rear hood, 28 foot table provided with down draught, projecting spectroscope and polariscope, etc. The building also contains four private laboratories, two store rooms, a dark room, a balance room and a private office for the director. The three rooms not yet fitted up are all of large size. The laboratories are ventilated by a large Sturtevant centrifugal exhauster, driven by an electric motor; all the rooms are wired for light and for power, and are heated by steam. Gas is furnished by a 100-light Detroit combination machine. The total cost of building, furniture, apparatus and chemicals was $22,500.

The trustees of Williams College met in New York City on November 8, with a view to selecting a president for the College, but were unable to come to a decision. Of the fifteen trustees in attendance it is said that five voted for Dr. E. H. Griffin, professor of the history of philosophy at the Johns Hopkins University and dean of the college faculty, and three for Dr. Henry Lefavour, professor of physics at Williams College and dean of the faculty.

In the Medical Department of the University of Pennsylvania Dr. Charles Mills has been appointed clinical professor of nervous diseases, in the place of Dr. Horatio Wood, resigned; Dr. W. G. Spiller, assistant professor of nervous diseases, and Dr. Charles Burr, professor of mental diseases.

Assistant Professor S. Lawrence Bigelow has been made acting director in charge of general chemistry at the University of Michigan during Professor Freer's absence in the Philippines. Mr. A. M. Clover has been appointed acting instructor in chemistry. R. T. Sanford and N. F. Harriman have been appointed assistants in the chemical laboratory.

A. B. Macallum, Ph.D., has been promoted to a full professorship of physiology in the University of Toronto.

The following appointments have been recently made at the University of Oregon: E. D. Ressler, A.M. (Ohio State University), assistant professor of education; Henry D. Sheldon, Ph.D. (Clark), assistant professor of philosophy and education; Richard H. Dearborn, B.S. (Cornell), instructor in electric engineering; Charles W. M. Black, Ph.D. (Harvard), instructor in mathematics; Orin F. Stafford, A.B. (Kansas), instructor in chemistry; Percy P. Adams, A.B. (University of Oregon), assistant instructor in civil engineering; Archibald A. Atkinson, A.B. (Pacific University), assistant instructor in biology; P. Irving Wold, B.S. (University of Oregon), assistant instructor in physics; R. R. Renshaw, scholar and assistant in chemistry.

Professor J. B. Garner, of the Bradley Institute at Peoria, has been appointed professor of chemistry in Wabash College.

Mr. Lyman F. Morehouse, an assistant in the physical department of the University of Michigan, has accepted a position as an instructor at Washington University, St. Louis. Mr. Lindley Pyle will fill the vacancy at the University of Michigan.

Philip B. Hawk, M.S., has been elected to succeed W. D. Cutler, A.B., as assistant in the department of physiological chemistry of Columbia University, at the College of Physicians and Surgeons.

Clark Wissler, A.B. (Indiana), Ph.D. (Columbia), has been appointed instructor in psychology in the Schoo o Pedagogy of New York University, and Dr. J. E. Lough has been promoted from an instructorship to an acting professorship.

Professor Hugh L. Callendar, F.R.S., has been appointed to the professorship of physics in the Royal College of Science, vacant by the resignation of Professor Rücker, who has become principal of the University of London.